NOAA TECHNICAL MEMORANDUM

NMFS-SEFSC-307

INTERACTIONS BETWEEN SEA TURTLES AND THE SUMMER FLOUNDER TRAWL FISHERY, NOVEMBER, 1991 - FEBRUARY, 1992

A Joint Report from

NOAA, NATIONAL MARINE FISHERIES SERVICE
SOUTHEAST FISHERIES SCIENCE CENTER
BEAUFORT LABORATORY

and

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT,
HEALTH AND NATURAL RESOURCES
DIVISION OF MARINE FISHERIES

JULY, 1992

U.S. Department of Commerce

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National Marine Fisheries Service

Southeast Fisheries Science Center

Beaufort Laboratory

Beaufort, North Carolina 28516

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TABLE OF CONTENTS

Introduction.....1

The Physical Environment.....5

Fishing and Observer Effort.....6

Fishery/Sea Turtle Interactions.....8

Strandings.....11

Aerial Surveys.....14

Summary.....15

Acknowledgments.....17

Literature Cited.....18

Tables.....24

Figures.....35

Appendixes

A. N.C. Division of Marine Fisheries/National Marine Fisheries Service Cooperative Sea Turtle Monitoring and Action Plan.....51

B. Chronology of Management Actions for the Summer Flounder Trawl Fishery, October, 1991 - March, 1992.....55

INTERACTIONS BETWEEN SEA TURTLES AND THE SUMMER FLOUNDER TRAWL FISHERY, NOVEMBER, 1991 - FEBRUARY, 1992

INTRODUCTION

In 1988 Congress reauthorized the Endangered Species Act (PL93-205) and mandated that a study be conducted to review information on the conservation of sea turtles and the causes and significance of turtle mortality. The study, conducted under the auspices of the National Academy of Sciences, concluded that shrimp trawling was the major source of human-associated mortality for sea turtles in U.S. coastal waters (Magnuson et al., 1990). They recognized that other fisheries contributed to the decline of turtle stocks, and specifically cited the winter trawl fishery for summer flounder, Paralichthys dentatus, near Cape Hatteras (Fig. 1) as an example. Their report emphasized the need to collect information on the incidental capture of sea turtles by these other fisheries.

The summer flounder trawl fishery is active from Georges Bank to Cape Lookout, North Carolina. It is but one component of a multi-gear, multi-species ocean trawl fishery in that area (Mid-Atlantic Fishery Management Council, 1988; Ross et al., 1990). In the fall and early winter, the fishery occurs nearshore south of Delaware Bay, moving farther southward as cooling water temperatures influence the movement of summer flounder (Mid-Atlantic Fishery Management Council, 1988). Typically, the fishery operates almost entirely off the North Carolina coast by late November. By late January to mid February the fishery usually moves northward and offshore to waters in the vicinity of Norfolk and Washington Canyons (Fig. 1). As waters warm in the spring, the fishery moves northward and inshore (Mid-Atlantic Fishery Management Council, 1988; Ross et al., 1990). The North Carolina component of the nearshore summer flounder trawl fishery is active predominately during October-February with landings from the deepwater fishery continuing through April (Table 1) (Ross et al., 1990).

States along the southern part of the Middle Atlantic Bight have generally restricted trawling nearshore. The territorial sea (0-3 nm of shore) of Delaware has been closed to trawling since 1966 (Delaware Code Title 7, Subsection 910; Charles A. Lesser, Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife, personal communication). Between 1968 and 1976, trawling was prohibited within 1.5 mi of shore in Maryland tidal waters, and between 1929 and 1976 all tidal waters were closed (Steve Early, Maryland Department of Natural Resources, Fisheries Division, Tidewater Administration, personal communication). Since 1976, Maryland has prohibited trawling

within 1 mi of shore (Annotated Code of Maryland, Section 4-710(b) of the Natural Resources Article). Virginia closed its territorial sea to trawling in 1989, in part, to conserve summer flounder stocks (Virginia Marine Resources Commission Regulation 450-01-0055). North Carolina has prohibited the use of trawls within 0.5 mi of the beach between the Virginia line and Oregon Inlet since 1966 [North Carolina Administrative Code 15A 3J.0202(2); Juanita Gaskill, North Carolina Department of Environment, Health and Natural Resources, Division of Marine Fisheries, personal communication].

Turtles may be found in the summer flounder trawl fishing grounds throughout the fall and winter. Coastwide aerial surveys north of Cape Hatteras indicate a seasonal migration of loggerhead sea turtles into and emigration out of the Middle Atlantic Bight that corresponds with warming and cooling water temperatures (Shoop and Kenney, 1992). Telemetry and stranding data indicate sea turtles leave Long Island Sound in October (Standora et al., 1992). From aerial surveys and reported sightings, sea turtles are known to emigrate from Chesapeake Bay by November (Lutcavage and Musick, 1985; Keinath, 1987) and from North Carolina sounds by late December (Epperly et al., 1990, 1992). Although many turtles appear to migrate as far south as Florida, evidence suggests that at least some turtles remain offshore throughout the South Atlantic Bight (Thompson, 1984; Epperly et al., 1989, 1990, 1992; NMFS, Galveston Laboratory, unpublished data).

There appears to be a relationship between trawling activity in coastal waters and strandings of sea turtles. Turtle strandings on the ocean beaches between Delaware Bay and Cape Lookout generally peak in the fall and early winter (Schroeder, 1987; Schroeder and Warner, 1988; Teas and Martinez, 1989, 1992) coincident with the activity of the summer flounder trawl fishery. Ocean beach strandings in Virginia have declined markedly since the 1989 closure of the territorial sea to trawling (Keinath et al., 1992). There are two peak stranding periods on North Carolina beaches. The first peak occurs in summer on the beaches of the central and southern coasts (Street, 1987; Schroeder, 1987; Schroeder and Warner, 1988; Teas and Martinez, 1989, 1992; Epperly et al., 1990;), and is temporally disjunct from the summer flounder trawl fishery. The second peak occurs in late fall and early winter on the northern ocean beaches of the state (Ibid.), concurrent with offshore activity of the summer flounder winter trawl fishery.

Several major stranding events have occurred in the late fall and early winter on the northern coast of North Carolina (Table 2). One hundred and forty-four turtles stranded during November and December, 1982 (Crouse, 1985), but the cause was not conclusively identified (Deborah T. Crouse, Center for Marine Conservation, personal communication). Trawler captains had reported high catches of turtles during November, 1982 off Ocracoke Island in

waters of greater than 14°C (58°F), but 90% or more were reportedly released alive (memorandum from M. W. Street, NCDMF, to D. Crouse, January 18, 1983). Crouse cited warmer than normal water temperatures as a corollary to the stranding event. Since the 1982-83 season, an average of 48 turtles have stranded annually; strandings were especially high in 1985-86 (89) and 1990-91 (90) (Table 2).

The summer flounder fishery has been regulated and managed through the federal permitting system since September 1988, when NMFS approved the original Fishery Management Plan for the Summer Flounder Fishery (FMP) (Mid-Atlantic Fishery Management Council, 1988). Prior to approval of the FMP, the fishery and proposed management activities were considered by NMFS Northeast Regional Office for their potential effects on endangered species, as required by Section 7 of the Endangered Species Act. NMFS issued a biological opinion that the summer flounder fishery interacted with sea turtles in some years when climatological conditions concentrated the flounder and sea turtles on the narrow continental shelf off Cape Hatteras (NMFS, 1988). NMFS concluded that apparent take levels would not jeopardize the continued existence of any populations of threatened or endangered species.

In 1990, 51 turtles, including eight Kemp's ridleys (Lepidochelys kempi), stranded between November 28 and December 6. Examination of high-resolution sea surface temperature (SST) images indicated the presence of a strong intrusion of Gulf Stream water in Raleigh Bay. In response to the strandings [North Carolina state law (G.S. 113-189; NCAC 15A 3I.0007(b)) provides for the protection of sea turtles], the North Carolina Division of Marine Fisheries (NCDMF) consulted with the National Marine Fisheries Service (NMFS), and closed the territorial sea to trawling between Cape Hatteras and Ocracoke Inlet on December 7. In addition, NCDMF initiated an experimental trawling program, and obtained assistance from the NMFS Beaufort Laboratory to conduct aerial surveys for turtles in the territorial sea. The Virginia Institute of Marine Science was contracted by NMFS to conduct aerial surveys extending into the EEZ (U.S. waters seaward of the territorial sea). The NCDMF reopened the territorial sea to vessels trawling with Turtle Excluder Devices (TEDs) on December 26. All restrictions were lifted on January 16, 1991 after nearshore sea surface temperatures decreased and catch rates on experimental trawls and sightings from aerial surveys in the territorial sea declined.

The NMFS Northeast Regional Office reinitiated consultation regarding summer flounder fishing activities, as required by Section 7 of the Endangered Species Act, because of the documented interaction between the summer flounder fishery and sea turtles (high catch rates and number of strandings, and the relatively high proportion of Kemp's ridley turtles caught and stranded). As a result of this consultation, a jeopardy opinion was issued after

NMFS determined that unregulated activity of the fishery could jeopardize the continued existence of the endangered Kemp's ridley sea turtle population (NMFS, 1991). Reasonable and prudent alternatives to unregulated fishing activities were listed that would allow fishing to continue. Additionally, an incidental take allowance of observed lethal takes of either five Kemp's ridley, five green, five leatherback or five hawksbill sea turtles, or 15 loggerhead sea turtles was issued. This allowance was dependent on monitoring and resuscitation requirements (NMFS, 1991). NMFS is required to reinitiate consultation once incidental take allowances are exceeded.

Prior to the 1991-1992 season, NCDMF and NMFS Beaufort Laboratory developed a plan to monitor and manage the fishery/turtle interaction (Appendix A). The problem was considered to be intermittent, related to seasonal shifts in the distribution of sea turtles or the fishery, and influenced by infrequent intrusions of Gulf Stream water. In October, 1991, trawling in the territorial sea of North Carolina north of Ocracoke Inlet was limited by NCDMF to tows of a maximum of 75 min duration (including time to set and retrieve gear) to protect turtles, should they be caught. In early December, the U.S. Department of Commerce issued an Emergency Interim Rule for the EEZ (Amendment 2 of the summer flounder FMP, containing sea turtle conservation measures for the fishery, had yet to be accepted by NMFS) which, in part, extended the 75 min tow limitation to 10 mi from shore between Cape Charles, Virginia to the North Carolina/South Carolina border. Federal and North Carolina biological observers were placed aboard vessels on a voluntary basis, and a program of aerial surveys was implemented. Incidental take of sea turtles was monitored daily. Observers radioed the U.S. Coast Guard each morning to report turtle catches of the previous 24 hr. In turn, the Coast Guard transmitted the information to both NMFS and NCDMF. SST images were examined daily at the NMFS Beaufort Laboratory. By late December, tow time restrictions were rescinded north of Oregon Inlet in both the territorial sea and the EEZ due to the low number of incidental captures. In early January, the flounder trawl fleet was operating in waters where sea turtles were sighted during aerial surveys, but vessels no longer were volunteering to carry observers. Therefore, NMFS and NCDMF could no longer monitor incidental take. In late January, mandatory observer coverage in both state and Federal waters was instituted by NMFS and the NCDMF. This program ended less than a month later and the fishing industry agreed to take observers voluntarily. In early March, NCDMF rescinded all restrictions in the territorial sea. The Federal Emergency Interim Rule affecting the EEZ was extended through June 3, 1992. A chronological listing of management actions is given in Appendix B.

This report completes the activities outlined in the NCDMF/NMFS Cooperative Sea Turtle Monitoring and Action Plan (Appendix A). The results of the monitoring activities of the

1991-1992 summer flounder trawl fishing season are presented herein.

THE PHYSICAL ENVIRONMENT

The entire South Atlantic Bight (West Palm Beach, Fla. to Cape Hatteras) is greatly influenced by the Gulf Stream (Bumpus, 1973). The narrower the continental shelf, the greater the effect of Gulf Stream water on nearshore processes. The Gulf Stream normally flows northward (approx. 40 cm/sec) roughly parallel to the edge of the continental shelf (Fig. 2A) and its location can be highly variable (Pietrafesa and Janowitz, 1980; Lee and Atkinson, 1983; Pietrafesa, 1990). The 200 m isobath delimiting the seaward edge of the continental margin ranges from 30-63 km offshore between Cape Hatteras and Cape Lookout (Raleigh Bay) (Fig. 1). This is the narrowest shelf region north of Cape Canaveral. North of Cape Hatteras the Gulf Stream usually veers to the northeast and separates from the continental margin.

Gulf Stream water also reaches the shelf and upper slope north of Cape Hatteras (Fig. 2B). Churchill and Cornillon (1991) detected Gulf Stream water up to 25% of the time on the shelf just north of Cape Hatteras, and detected it up to 27% of the time on the upper slope 80-300 km north of Cape Hatteras. This water was significantly less dense than shelf water of equivalent depth. Consequently, the circulation associated with this density contrast acted to advect shelf water seaward of the continental margin.

In the South Atlantic Bight, the density gradient between nearshore waters and Gulf Stream waters is temperature controlled (Lee et al., 1981; Pietrafesa et al., 1985) and is strongest in the winter. Surface water temperatures in Raleigh Bay are highly influenced by the proximity of the Gulf Stream. The warmer, less dense water of the Gulf Stream overrides the colder, more dense shelf waters. Characteristically, the surface waters of Raleigh Bay are far warmer in the winter than bays to the south where the continental margins are >90 km wide (see Pietrafesa et al., 1985; see Churchill and Cornillon, 1991; see Tester et al., 1991; unpublished SST imagery archived at NMFS, Beaufort Laboratory) (Fig. 2A,C).

Two different episodic, physical processes can influence the "normal" winter condition of warm surface waters in Raleigh Bay, described above. The first is a shoreward movement of the Gulf Stream front in the form of meanders. These consist of anticyclonically flowing meander "crests" of near-surface Gulf Stream water, 15-20 m deep, which can extend to the shore (Pietrafesa, 1989, 1990). These Gulf Stream meanders or filaments appear as amplified waves and occur in the time scale of 2-14 days

(Lee et al., 1981; Pietrafesa and Janowitz, 1980), and can introduce warm (20-25°C) water directly into the nearshore waters of Raleigh Bay. They can be recognized easily from SST images (Fig. 2A, "normal" conditions with Gulf Stream flowing at the edge of the continental shelf and warm surface water in Raleigh Bay; Fig. 2C, a very strong outpocketing of the western edge of the Gulf Stream into Raleigh Bay; Fig. 2D, filaments of very warm (Gulf Stream) water override the entire continental shelf of Raleigh Bay influencing the nearshore waters adjacent to the barrier islands).

The second process influencing the hydrographic regime of Raleigh Bay is winds. In winter, strong winds from the north and northeast push low salinity cold water (Virginia Coastal Water) from the Middle Atlantic Bight around Cape Hatteras and along the nearshore to outer shelf areas of Raleigh Bay (Fig. 2E; Pietrafesa, 1989; Pietrafesa et al., 1992). Generally, the winds must be sustained and uninterrupted by strong winds from the south for this to happen to any great extent (Fig. 3; Bumpus, 1955; Stefansson et al., 1971; Pietrafesa et al., 1992). After the northerly winds subside, the Gulf Stream water once again can override the surface waters of Raleigh Bay and the relaxed or "normal" hydrographic conditions can recur (Fig. 2F).

FISHING AND OBSERVER EFFORT

State and Federal port agents in Virginia and North Carolina recorded landings and estimated the number of trips landed by the flounder trawl fishery (Table 3). In Virginia the fleet off-loaded catches mainly in the Hampton, Va. area; in North Carolina the major ports were Wanchese, Beaufort-Morehead City area, and ports along the western perimeter of Pamlico Sound (Fig. 1). From October, 1991 through April, 1992, 1098 trips were reported (Table 3). Landings in Virginia represented the effort of 94 trawl vessels, although for some, flounder were a bycatch. There is no estimate of the number of vessels operating out of North Carolina ports, but many are reflected in the Virginia total because vessels landed in both states. In addition, approximately 14 vessels operated opportunistically only in the Hatteras Bight and landed exclusively in North Carolina (James P. Monaghan, Jr., NCDMF, personal communication). [The Hatteras Bight is the area south of Cape Hatteras and offshore of Ocracoke and Hatteras Islands (Fig. 1)].

Trawl vessels were enumerated at sea in directed overflights (Table 4). It was not possible to distinguish the type of trawl from the air. Therefore, the counts necessarily included vessels using flynets as well as flounder nets. Overflights by NCDMF

utilized single-engine aircraft, and therefore, were limited to the territorial sea due to safety considerations. Overflights by NMFS, utilizing twin-engine aircraft, began in January and surveyed waters to at least 28 km from shore. Hence, on the two days when both agencies conducted flights (Jan. 6, Feb. 20), the NMFS survey yielded a higher vessel count. As many as 46 vessels were sighted during one flight, and based on NMFS flights during January-February, an average of 28 vessels operated daily south of Cape Charles (Table 4). Vessels were often aggregated, particularly in the Hatteras Bight and in the area between Oregon Inlet and Wimble Shoals. Some vessels continued to work south of Cape Hatteras through early March.

Overflights identified 68 vessels that held Federal permits to fish for summer flounder. These identified vessels were subject to mandatory observer coverage for a period of 3 wk. An additional nine vessels which were not Federal permit holders were permitted by NCDMF to fish for summer flounder only in the territorial sea. During the 3 wk period of mandatory coverage, 53 vessels reported 101 trips to NMFS Northeast Regional Office or NCDMF. Observers were aboard 17 of the trips.

Between November and February, observers were aboard 42 (5.9%) of the 714 trips reported (Table 3). Observers recorded duration and location of each haul, and catch by net. Sea turtles were identified, measured, and tagged, and resuscitated when necessary. Dead turtles were placed on ice and returned to shore for necropsy. Trips ranged from 1 to 15 days in duration, and averaged 5 days. Trawls used in the fishery varied in design, size, and method of rigging. Headrope lengths ranged from 15-35 m. Observed trips ranged in latitude from 34°22.8′N to 38°28.2′N (Fig. 4) and represented 1397 nets towed (1058 actual hauls; some hauls were made with two nets) and 2745 net hours of actual towing (Table 5). There were 167 hauls observed north of Cape Charles, 466 hauls observed between Cape Charles and Cape Hatteras, and 425 hauls observed south of Cape Hatteras. Haul locations illustrated a latitudinal pattern with deep water tows to the north and shallow water tows to the south. Most hauls north of Cape Charles (83%) were in deep water (>50 m) (Fig. 4). Hauls between Cape Charles and Cape Hatteras generally were in waters less than 50 m (96%) and hauls south of Cape Hatteras generally were in waters less than 20 m (87%). North of Cape Hatteras, most hauls were in the EEZ; south of Cape Hatteras most hauls were, at least in part, within the territorial sea (Table 6). Both beginning and ending locations of a tow track were recorded on only 69% of the hauls, and most of the omissions were for hauls south of Cape Hatteras.

FISHERY/SEA TURTLE INTERACTIONS

Turtles were caught throughout the entire period of monitoring, and a total of 83 turtles were brought aboard trawlers with observers (Table 7, Fig. 5). Observers tagged and released 70 turtles with inconel tags placed in both rear flippers. The sea turtle catch comprised loggerhead sea turtles (Caretta caretta) (60%), Kemp's ridley sea turtles (Lepidochelys kempi) (35%), green sea turtles (Chelonia mydas) (2%), and a hawksbill sea turtle (Eretmochelys imbricata) (1%) (Table 7). Most (80%) of the turtles were caught south of Cape Hatteras, but turtles were caught as far north as 36°12.36'N (Fig. 5). When tow time restrictions were rescinded for the area north of Oregon Inlet (26-27 December; Appendix B), five turtles - all loggerheads - had been captured north of the inlet; subsequently no more were reported. The last turtle was caught on February 14 off Cape Lookout and the last observer returned on February 20. Catches north of Cape Hatteras were almost exclusively loggerhead sea turtles (Table 7). Catches south of Cape Hatteras were more diverse, at least in the first half of the monitoring period. Unlike other areas or time periods, Kemp's ridley sea turtles accounted for 60% of the catch south of Cape Hatteras in November-December, 1991. These catches represented a much greater proportion of Kemp's ridleys than has been reported in Pamlico and Core Sounds (2-11%; Epperly et al., 1992) and in Chesapeake Bay (15%; Keinath et al., 1987). No Kemp's ridley turtles were caught after January 21. Catches south of Cape Hatteras in January and February, 1992 were predominately of loggerhead sea turtles. Except for two loggerhead sea turtles which were >80 cm carapace length over the curve (CCL), captured turtles of all species were juveniles and subadults. Loggerhead turtles ranged in size from 24-90 cm, and averaged 60 cm CCL (Fig. 6). Kemp's ridley turtles ranged in size from 25-64 cm and averaged 41 cm CCL (Fig. 7). The two green turtles were 26 cm and 28 cm CCL and the single hawksbill turtle was 30 cm CCL.

Experimental (those with 6 in spacing between the bars) and NMFS certified TEDs (those with 4 in spacing between the bars) were used on five of the observed trips. Four turtles were captured in TED-equipped nets: two Kemp's ridley turtles, (37 and 38 cm CCL) and the hawksbill turtle were captured in a Jones TED with 6 in spacing between the bars; one Kemp's ridley turtle (39 cm CCL) was captured in an Anthony TED, also with 6 in spacing between the bars. No turtles were retained in the 30 hauls made with nets equipped with TEDs with 4 in spacing between the bars. The hawksbill turtle was the only mortality in a TED-equipped net. Gear testing for the development of a suitable TED for the summer flounder fishery has begun (Watson, 1992).

Trawling effort was standardized following the methods outlined in Henwood and Stuntz (1987), and catch rates were

calculated (Table 8). Catch-per-unit effort estimates did not include effort and catch by TED-equipped nets. The unweighted overall catch rate for the entire fishery operating south of Cape Charles was 4.8 turtles per 100 hours of towing. This value is comparable to those reported for the Atlantic shrimp fishery by Henwood and Stuntz (4.9; 1987), Renaud et al. (3.0; 1990), and Renaud et al. (3.8; 1991), but is much lower than 56 turtles per 100 hours reported for the Cape Canaveral ship channel (Butler et al., 1987). However, south of Cape Hatteras in November-December, catch rates were greater than 17 turtles/100 hrs, and catch rates were greater for Kemp's ridley sea turtles than for loggerhead sea turtles (Table 8). These catch rates were comparable to 24 turtles/100 hrs (14/100 hrs for loggerheads turtles and 10/100 hrs for Kemp's ridley turtles) obtained by NCDMF while conducting experimental tows in 54 hrs of effort in December, 1990 in the same area [standardized rates were calculated from data presented in Monaghan (1991) and NCDMF (1991)]. Catch rates south of Cape Hatteras were 6-8 times greater than catch rates north of Cape Hatteras.

To estimate the total number of turtles caught from November, 1991-February, 1992 for vessels landing in North Carolina and Virginia, stratified random survey techniques were used (Cochran, 1977). Catch was compiled for vessels landing in North Carolina and Virginia ports separately for November-December, 1991 and January-February, 1992 time periods. Within each of the four strata, catch estimates were based on the proportion of observed trips to the total reported landed (Table 3). Underlying assumptions were that estimates of the total number of trips within strata were accurate and that the observed trips were a random sample (i.e. representative in location of fishing, duration of trip, size and rigging of nets, length of tow, catch, care of turtles, resuscitation success, etc.) of the entire fleet landing in the same area during the same time period. There were no performance data available for the fleet at large with which the latter assumption could be evaluated. Ninety-five percent confidence intervals for these estimates were derived using a procedure called bootstrapping, a non-parametric, simulated resampling technique (Efron and Gong, 1983; Efron and Tibshirani, 1986). Trips were resampled (n=10,000 iterations) within the hypothetical populaton of each stratum, which were constructed from the observer data. Based on these analyses, a total of 1063 turtles (95% C.I.= 529-1764) were estimated to have been caught during this portion of the fishery. Based on the stratified mean number of turtles caught per trip, the rate of encounter was approximately 1.5 turtles per trip. Individual stratum values were 4.1 turtles per trip for N.C.-1991, 1.5 turtles per trip for N.C.-1992, 0.3 turtles per trip for Va.-1991, and 0.3 per trip for Va.-1992.

Catch rates were highest in shallow waters (Fig. 8). Turtles were captured in depths from 9 to 34 m; the range of depths trawled

was 6 to 98 m. Catch rates were highest in warmer waters, although turtles were caught in temperatures as low as 10°C (Fig. 9). The water depth and temperature ranges of waters in which Kemp's ridley turtles were captured were narrower than the ranges for loggerhead turtles (Figs. 8 and 9). Except for those turtles which were comatose or dead, turtles were generally active - not the behavior of brumating turtles (Felger et al. 1976; Carr et al., 1980) (brumation is winter dormancy in ectothermic vertebrates), and had been on the bottom - not the behavior of cold-stunned turtles (Schwartz, 1978).

All but seven of the turtles captured were returned to the sea alive. Overall, about 9% (n=7) of those released had to be resuscitated. The death rate (8.6%) was less than that reported for an unregulated shrimp fishery (23.4%) (Henwood and Stuntz, 1987). The relatively few mortalities observed were attributable, in part, to the presence of tow time restrictions and observers trained to resuscitate comatose turtles. Both studies assumed resuscitated turtles lived, but Magnuson et al. (1990) summarized data to the contrary. Thus, if resuscitated turtles later died, or if other fishermen failed to attempt resuscitation on comatose turtles, the death rate in the summer flounder trawl fishery could have been twice that observed. Necropsies conducted by the Virginia Institute of Marine Science on five of the dead turtles (the hawksbill and one loggerhead sea turtle were not returned to shore) indicated that the turtles were relatively healthy prior to their deaths, and all had food remains in their digestive tracts. In one instance, the lungs were still inflated; in another, the cause of death was severe trauma, perhaps incurred when the turtle was brought on deck. Two of the mortalities, a partially decomposed loggerhead turtle and a Kemp's ridley turtle with rigor mortis, were dead prior to their capture.

Henwood and Stuntz (1987) demonstrated a strong positive relationship between tow time and incidence of sea turtle mortality in the shrimp fishery. Their estimates were based on over 27,000 hours of observed trawling effort. Because numerically few mortalities were observed during the flounder trawl fishery (perhaps a function of the relatively low observed effort - less than 2800 hrs), no pattern of deaths could be discerned (Fig. 10). Resuscitation rates were relatively high in 60 min tows (actual time on bottom). On one trip during which total tow times never exceeded 75 min, the proportion resuscitated was 17% (4 of 23 turtles), one turtle died, and two previously dead turtles were caught. High rates of resuscitation and a death in short tows indicate the presence of stressed animals, perhaps related to multiple captures of individual turtles in combination with warm water temperatures. Multiple captures increase physiological stress by depriving turtles of sufficient time to recover (Magnuson et al., 1990) and stress is aggrevated by warm water temperatures, like those present in the Hatteras Bight. The capture of

previously dead turtles in the same fishing area is evidence of intensive trawling effort in the relatively small area of the Hatteras Bight. Throughout the study period, observers reported as many as 30 other vessels trawling within sight of their vessel during a 24 hr period, and directed overflights revealed that trawlers were generally aggregated. However, none of the 70 turtles tagged and released throughout the monitoring period were recaptured by observers or reported from other sources. The lack of recaptures can be an indication of 1) a large population of turtles in the area, 2) behavorial modification of turtles with tags such that they would be less vulnerable to trawls, 3) high mortalities sustained by the tagged turtles, or 4) non-reporting of recaptures by vessels not carrying observers. One sea turtle, a Kemp's ridley that had been tagged and released off Long Island, N.Y. on August 5, 1991 (Stephen J. Morreale, Okeanos Research Foundation, personal communication), was reported recaptured by a trawler not carrying an observer, and released alive east of Cape Hatteras the last week of November.

Lethal take was estimated for the entire fishery using the same stratified random and bootstrapping techniques explained earlier. Two analyses were conducted. The first assumed that all resuscitated turtles lived. The second, conducted to provide an estimate of the upper limit of mortality, assumed that all resuscitated turtles later died (see Magnuson et al., 1990). Using these two methods, 89 (95% C.I.= 22-171) and 181 (95% C.I.= 56-342) turtles, respectively, were estimated to have died as a result of the winter trawl fishery for summer flounder during November, 1991-February, 1992 (Table 9). The estimates for Kemp's ridley sea turtles were zero and 56 dead, respectively. The mean number of dead or comatose turtles per fishing trip was 0.25 (1 turtle per 4 trips). The individual stratum estimates are 0.7 for N.C.-1991, 0.1 for N.C.-1992, 0.2 for Va.-1991, and 0.0 for Va.-1992.

STRANDINGS

Strandings throughout the Atlantic and Gulf of Mexico have been reported by volunteers in the Sea Turtle Stranding and Salvage Network (STSSN) since 1980 (Schroeder, 1989). The majority of North Carolina beaches north of Cape Lookout are Federal lands and generally have good coverage by the STSSN because of the involvement of the National Park Service. However, beaches to the north, particularly those of Delaware and the eastern shore of Virginia have less than complete coverage by the STSSN. In 1991, the pattern of strandings on the ocean beaches south of Delaware Bay appeared to follow the inshore and southward movement of the flounder trawl fishery fleet. Strandings peaked in September-

October in Maryland (Cindy P. Driscoll, Maryland Department of Natural Resources, personal communication) and Virginia (John A. Keinath, Virginia Institute of Marine Science, personal communication), and in October-December in North Carolina, north of Cape Lookout (Tom Henson and Therese Conant, North Carolina Wildlife Resources Commission, personal communication). In 1991, no strandings were reported in Delaware (Lisa A. Gelvin-Innvaer, Delaware Department of Natural Resources, personal communication) and none were reported in Maryland prior to September (eight loggerhead turtles stranded in the fall). Even with the closure of its territorial sea to trawling, Virginia experienced two stranding peaks in 1991. During the fall peak, six loggerhead turtles stranded in September, ten loggerheads and two Kemp's ridley turtles stranded in October, and five loggerheads, one Kemp's ridley and one leatherback sea turtle stranded in November. These strandings may indicate sources of mortality other than trawling, or possibly illegal trawling.

Twenty-five turtles stranded on North Carolina beaches north of Cape Lookout during the 1991-1992 summer flounder trawl fishing season (Table 2) (Fig. 5); all but one were loggerheads. In October, six turtles stranded between the N.C./Va. state line and Oregon Inlet, and three stranded south of C. Hatteras. In November, four turtles stranded just north of Oregon Inlet and one turtle stranded south of Ocracoke Inlet. The four strandings south of Cape Hatteras during October and November probably were not related to flounder trawling, because the fleet was working north of Cape Hatteras until late November. In December, fishing activity was split between the Hatteras Bight and the Wimble Shoals-Oregon Inlet area and five turtles stranded along the beaches of the Hatteras Bight and two stranded north of Cape Hatteras. One turtle stranded midway between Oregon Inlet and Cape Hatteras in early January, 1992, and three stranded along the beaches of the Hatteras Bight in March (1) and April (2).

Strandings have been used as an index of at-sea mortality from shrimping activities (Murphy and Hopkins-Murphy, 1989; Magnuson et al., 1990; Caillouet et al., 1991), but are subject to error due to many factors. Wind and currents are perhaps most important, because through their influence dead turtles may be transported some distance before stranding or might never strand. Murphy and Hopkins-Murphy (1989) reported that only six of 22 tagged loggerhead turtle carcasses released at sea were reported as strandings. Also, Renaud et al. (1990; 1991) reported that four fresh dead turtles were painted and released overboard, but were never reported stranded. Thus, the number of stranded sea turtles represents a minimum measure of mortality. Based on the results presented by Murphy and Hopkins-Murphy (1989), the estimate of 4:1 was used by the National Academy of Sciences review committee to estimate mortality from various sources (Magnuson et al., 1990).

The 25 strandings in North Carolina may be a very conservative index of the at-sea mortality. Evidence suggests that not all turtles which died as a result of the summer flounder trawl fishery washed ashore. The dead hawksbill turtle was released at sea and was not reported stranded. The size distribution of stranded loggerhead turtles and the species composition of the reported strandings also indicate differences between strandings and observed at-sea mortalities. Comparison of size distributions of stranded and incidentally caught loggerhead sea turtles indicated that loggerheads reported stranded were generally larger than loggerheads observed in the catches of the summer flounder trawl fishery (Fig. 6). Based on observed and estimated catches and mortalities (Tables 8 and 9) - Kemp's ridley sea turtles accounted for 60% of the catch in the Hatteras Bight during November and December - one could expect numerous Kemp's ridleys to have stranded, but none were reported. One previously dead Kemp's ridley turtle was caught and four were resuscitated by observers. Further, a Kemp's ridley turtle with a satellite tag was released off Long Island, N.Y. in September 1991, but disappeared in November southeast of Cape Hatteras (Stephen J. Morreale, Okeanos Research Foundation, personal communication). Prior to the disappearance, the satellite signal was intermittent, consistent with the coincidence of a live turtle surfacing when a receiving satellite was overhead. The signal disappeared for 13 days and then reappeared 500+ km to the northeast. Upon reappearance, the signal was continuous, indicating the transmitter was constantly at the surface without submergence - not the behavior of a live turtle. A tenable hypothesis is that the turtle died (cause of death unknown), sank to the bottom, decomposed, bloated, and floated to the surface. Bottom currents carried it offshore, into the axis of the Gulf Stream, not onshore.

A possible explanation for the discrepancy in number, size and species composition between the strandings and at-sea catches is the offshore movement of bottom water which would serve to transport lifeless turtles away from the beach. Such a scenario is consistent with our knowledge of the circulation of shelf water in the area. Under the relaxed "normal" winter conditions, density gradients between Gulf Stream water and nearshore waters result in an onshore movement of Gulf Stream water at the surface and an offshore movement of shelf waters along the bottom (Churchill and Cornillon, 1991). Similarly, there is an offshore movement of bottom waters when the area is influenced by Virginia Coastal Waters (Pietrafesa et al., 1985; Pietrafesa, 1989). The variability in strandings in the last decade may be attributable, in part, to the variability in the proximity of fishing and turtle interactions to shore. Dead or comatose turtles released nearshore could be more easily deposited on the beach by wind-dominated circulation which tends to dominate nearshore areas (Pietrafesa at al., 1985; Pietrafesa, 1989).

AERIAL SURVEYS

Aerial surveys were conducted by the NMFS Beaufort Laboratory following methodology established for surveys of Core and Pamlico sounds and the inshore waters of southern Georgia (Braun et al., 1990; Epperly and Braun, 1991). The coastal area was partitioned into five zones such that 10-20% visual coverage of a selected zone could be attained in a 3 hr flight. Initially, surveys of only the territorial sea were conducted using a single engine plane. By early December the flounder trawl fleet was operating in the EEZ, and twin engine aircraft were chartered to allow extention of the survey to 28 km from shore, almost 10 km seaward of the zone within which sea turtle conservation measures were implemented. Survey zones flown on any given day were chosen based on the known location of the fleet, reports of incidental captures, and examination of near real-time SST imagery. Concurrent surveys for marine mammals were conducted in the area in January. Turtle sightings in Raleigh, Onslow and Long Bays were recorded during these surveys, and were provided by the New England Aquarium (Scott Kraus, New England Aquarium, personal communication; with permission from Minerals Managment Service) and by NMFS, Miami Laboratory (Wayne Hoggard, NMFS, personal communication).

The number and density of turtles on the surface of a zone were estimated (Table 10). Turtles were present throughout the study period, at least as far north as Oregon Inlet. Surface densities ranged from 0 to 11 turtles/100 km^2. Musick et al. (1992) reported that surface densities of turtles on individual transects flown between Oregon and Ocracoke Inlets in December, 1990, were as high as 30 turtles/100 km^2. They did not report the mean density for the survey area. Sea turtles reportedly spend only 4-17% of their time on the surface (Kemmerer et al., 1983; Musick et al., 1983; Keinath et al., 1987). The surfacing behavior of the overwintering turtles may differ from these reported values, but most likely, the estimated number of sea turtles on the surface represents a small fraction of the turtles actually in the area.

Overlays of turtle sightings with available SST imagery indicated that turtles occurred in waters 6-24°C, but were most frequently located in waters greater than 10°C. When Gulf Stream influences reached within 28 km of shore in a survey zone (5 km in early surveys), turtles were sighted (Fig. 11A-F). Turtles were sighted consistently in Raleigh Bay and north of Cape Hatteras throughout the study (Fig. 11A,D,F). Turtles were sighted frequently along strong thermal gradients (Fig. 11B,D,E). No turtles were sighted between Oregon Inlet and Cape Hatteras on March 30 which followed a period of northerly winds (Fig. 3) that pushed cold Virginia Coastal Water southward, displacing the Gulf Stream waters to the east of the survey zone.

Sightings of sea turtles made during the marine mammal surveys also illustrate the association of turtles with Gulf Stream water (Fig. 11C,D). Favorable temperature regimes occur along the western edge of the Gulf Stream year-round throughout the South Atlantic Bight. Turtles have been sighted along the western wall of the Gulf Stream in winter aerial surveys conducted south of Cape Fear (Thompson, 1984), and no data existed previously for the northernmost area of the South Atlantic Bight. Surveys south of Cape Fear generally indicated an absence of turtles in nearshore waters where cold water discharged from the inlets mixed with ocean waters cooled by ambient air temperatures. In Raleigh Bay, the western edge of the Gulf Stream is generally closer to shore than in areas to the south; hence, turtles are at greater potential risk for interaction with nearshore fisheries due to the influence of the Gulf Stream on the nearshore waters. Turtles are not passive migrants, and apparently attempt to stay in relatively warm water. As warm Gulf Stream waters override the shelf, turtles appear to move shoreward. Conversely, when cold Virginia Coastal Water extends southward, Gulf Stream water and turtles are displaced offshore. Surface water temperatures can change dramatically over short time intervals. Surface water temperatures approximately 20 km from shore in the vicinity of Cape Hatteras cooled more than 10°C between January 30 and February 3, 1992 (unpublished SST imagery archived at NMFS, Beaufort Laboratory). Sightings of turtles in relatively cold water (Fig. 11F) provide evidence that these temperature shifts may occur so rapidly that turtles become separated from their preferred temperature regime.

SUMMARY

The winter trawl fishery for summer flounder was monitored for interactions with sea turtles November, 1991-February, 1992. The catch of sea turtles comprised loggerhead, Kemp's ridley, green, and hawksbill sea turtles. Turtles were caught as far north as 36°12'N, but most were encountered south of Cape Hatteras, where Kemp's ridleys accounted for as much as 60% of the catch in November and December. Expansion of the observed catches (81) provides an estimate of 1063 (95% C.I.= 529-1764) turtles caught by the fishery during the period of monitoring, which is an average catch of 1.5 turtles per trip. Ninety-two percent of the documented incidental captures were released alive, and about 9% had to be resuscitated. Estimates of total lethal take in the fishery ranged from 89 (95% C.I.= 22-171) to 181 (95% C.I.= 56-342) turtles, or 0.25 dead or comatose turtles per trip. At 5.9% observer coverage between November, 1991 and February, 1992, the incidental take allowed in the Biological Opinion for the Summer Flounder Fishery Management Plan was not exceeded.

The western edge of the Gulf Stream provides favorable temperature regimes for sea turtles throughout the South Atlantic Bight; sea turtles are present year-round in North Carolina coastal waters. In Raleigh Bay, the western edge of the Gulf Stream is generally closer to shore than in areas to the south. Sea turtles emigrating the Middle Atlantic Bight and the Pamlico-Albemarle Estuarine Complex must migrate along a very narrow shelf in the vicinity of Cape Hatteras. The narrow shelf and the influence of the Gulf Stream on the nearshore zone apparently serve to concentrate the sea turtles. Thus, sea turtles are a greater risk for potential interaction with fisheries active on the continental shelf in this area.

There were several paradoxes: 1) The relative abundance of Kemp's ridley sea turtles south of Cape Hatteras in 1991 was greater than the reported contribution of the species to the inshore sea turtle fauna of Pamlico and Core Sounds (Epperly et al., 1992), and of Chesapeake Bay (Keinath et al., 1987); 2) Turtles were sighted in waters as cold as 6°C and captured in waters as cold as 10°C, but did not show any signs of cold stunning or brumation; 3) Despite the documentation of aggregated fishing activity, none of the 70 turtles released with tags were reported recaptured; 4) The greatest proportion of comatose and dead turtles (21%) was on a single trip in which tow times never exceeded 75 min; 5) The number, species and size composition of stranded turtles differed from that projected from documented incidental captures at sea; and 6) North Carolina and Virginia experienced the same number of strandings (25) during the 1991-1992 fishing season, despite the closure of the Virginia territorial sea to trawling. These findings, which are inconsistent with previous perceptions or conclusions drawn from previous studies, need to be addressed in future studies.

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Table 1. Reported ocean trawl-caught flounder landed in North Carolina (1,000 of lbs), January, 1972 - April, 1992.

	MONTH											
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1972	516	121	96	185	18	0	0	0	0	17	230	2579
1973	2322	214	217	147	16	0	0	0	0	12	1858	1526
1974	2821	393	144	231	2	3	0	0	0	102	2130	4201
1975	2659	520	353	218	21	0	0	0	0	44	1616	4107
1976	2752	322	401	445	0	0	0	0	14	26	2094	3572
1977	1413	542	103	220	59	0	0	0	1	64	3726	4204
1978	1612	535	1265	933	87	130	16	19	132	481	1333	4277
1979	3562	1555	2394	1127	289	16	82	117	63	505	2538	3835
1980	3804	1652	952	333	108	74	0	0	*	245	1835	4640
1981	2449	1248	245	216	99	4	1	1	*	68	658	2462
1982	1165	685	464	350	138	*	0	*	*	8	931	2561
1983	1865	515	297	181	3	*	66	16	*	*	1068	3018
1984	4059	1212	623	523	169	*	*	*	181	243	1511	3933
1985	2942	1204	950	467	331	124	81	*	51	6	958	1483
1986	1947	894	595	442	174	90	17	*	122	108	582	946
1987	1450	468	203	145	11	*	*	*	125	321	803	1552
1988	1897	981	977	441	43	0	*	15	53	339	987	1035
1989	1419	817	262	218	29	*	*	0	*	190	489	765
1990	544	223	176	48	3	*	0	0	*	47	596	1085
1991	845	697	352	89	*	*	0	*	34	299	411	758
1992	530	275	220	49								

* confidential data are not included to avoid disclosure of private enterprise.

Table 2. Sea turtle strandings on North Carolina ocean beaches, Cape Lookout to N.C./Va. state line, October-April.

Fishing Season	Species										
	C. caretta		C. mydas		D. coriacea		L. kempi		Unknown		Total
	N	%	N	%	N	%	N	%	N	%	N
1979-80	4	100.00									4
1980-81											0
1981-82	19	100.00									19
1982-83	139	94.56	2	1.36	1	0.68	5	3.40			147
1983-84	32	100.00									32
1984-85	30	96.77							1	3.23	31
1985-86	84	94.38			1	1.12	3	3.37	1	1.12	89
1986-87	49	81.67	1	1.67			9	15.00	1	1.67	60
1987-88	17	62.96			1	3.70	8	29.63	1	3.70	27
1988-89	35	77.78	4	8.89			6	13.33			45
1989-90	20	58.82	13	38.24			1	2.94			34
1990-91	70	77.78	6	6.67			10	11.11	4	4.44	90
1991-92	24	96.00			1	4.00					25
Total	523	86.40	26	4.31	4	0.66	42	7.13	8	1.33	603

Table 3. Monthly summary of summer flounder trawl fishery trips reported landed in North Carolina and Virginia, and number of trips with observers, October, 1991 - February, 1992. Observers were aboard 42 of the 823 trips reported.

	North Carolina		Virginia	
Month	Number of Trips Reported	Number of Observed Trips	Number of Trips Reported	Number of Observed Trips
October, 1991	24	0	85	0
November, 1991	68	2	71	4
December, 1991	113	11	79	0
January, 1992	80	14	133	6
February, 1992	57	2	113	3
March, 1992	56	0	132	0
April, 1992	27	0	60	0

Table 4. Trawlers observed between Cape Charles, Va. and Cape Lookout, N.C. during NMFS and NCDMF overflights, November, 1991 - March, 1992. Trawlers were in the territorial sea unless noted.

Date	Source	Area				
		Cape Charles to N.C./Va. border	N.C./Va. border to Oregon Inlet	Oregon Inlet to Cape Hatteras	Cape Hatteras to Ocracoke Inlet	Ocracoke Inlet to Cape Lookout
November						
13	NCDMF	[a]	2	0	1	1
15	NCDMF	[a]	0	1+12[b]	0	0
19	NCDMF	[a]	6	33[b]	2	0
21	NCDMF	[a]	3	20	4	1
25	NCDMF	[a]	21+4[b]	3+8[b]		0
26	NCDMF	[a]	4	0	2	2
27	NCDMF	[a]	13	8+7[b]	4	0
28	NCDMF	[a]	13	8	2	0
29	NCDMF	[a]	8	2+2[b]	2	0
December						
4	NCDMF	[a]	11	1	5	0
5	NCDMF	[a]	4+6[b]	3[b]	20	1
9	NCDMF	[a]	10+14[b]	6+3[b]	13	0
11	NCDMF	[a]	2+1[b]	4+2[b]	17	1
13	NCDMF	[a]	1+2[b]	0	0	0
16a.m.	NCDMF	[a]	3	0	22	0
16p.m.	NCDMF	[a]	11	3	12	3
17	NCDMF	[a]	24	3	11	5+1[b]
18	NCDMF	[a]	19+13[b]	3+1[b]	6	1
23	NCDMF	[a]	1	0	0	0
26	NCDMF	[a]	0	3+2[b]	3	0
January						
1	NCDMF	[a]	0	0	11	0
6	NCDMF	[a]	2	8[b]	6[b]	2
6	NMFS	2[b]	2+8[b]	1+2[b]	6[c]	5+7[b]
7	NMFS	0	13	3[c]	3[c]	1+18[b,c,d]
8	NCDMF	[a]	0	5[b]	1+1[b]	0
9	NCDMF	[a]	0	0	9+4[b]	0
15	NCDMF	[a]	0	0	9	5
18	NMFS	[a]	7[b]	0	14+2[b]	1+8[b]
21	NMFS	3[b]	1+2[b]	5+7[b]	11	20[b]
25	NCDMF	[a]	[a]	0	4	0
27	NCDMF	[a]	3[b]		3	0
29	NCDMF	[a]	[a]	[a]	3	0
30	NCDMF	[a]	[a]	[a]	4[b]	0
31	NCDMF	[a]	[a]	[a]	1+1[b]	0
February						
3	NCDMF	[a]	[a]	0	7+2[b]	0
4	NCDMF	[a]	[a]	0	4[b]	0
5	NMFS	2[b]	2[b]	0	2[b,c]	1+3[b]
17	NCDMF	[a]	3	3[b]		0
20	NCDMF	[a]	[a]	12[b]	0	0
20	NMFS	5[b]	1+2[b]	0	11[b]	1[b]
27	NCDMF	[a]	[a]	0	0	0
March						
3	NCDMF	[a]	0	5[b]	4	0

[a] area not surveyed
[b] U.S. Exclusive Economic Zone (EEZ)
[c] includes trawlers previously observed in another area
[d] trawler observed in both the territorial sea and the EEZ

Table 5. Summary of observer effort in the summer flounder trawl fishery, November, 1991 - February, 1992. Note that a trip may include activity in more than one area.

	Area of Fishing		
	North of Cape Charles	Cape Charles to Cape Hatteras	Cape Hatteras to Cape Lookout
November-December, 1991			
trips	2	13	8
nets towed	13	313	296
net hours	16	969	319
January-February, 1992			
trips	7	14	17
nets towed	154	180	441
net hours	410	430	601

Table 6. Beginning and ending locations of observed hauls in the summer flounder trawl fishery south of Cape Charles, Va., November, 1991 - February, 1992. Number of hauls for each area are indicated.

	Ending Location of Tow					
	Cape Charles to Cape Hatteras			Cape Hatteras to Cape Lookout		
Beginning Location	Territorial Sea	EEZ <10 mi	EEZ ≥10 mi	Territorial Sea	EEZ <10 mi	EEZ ≥10 mi
Territorial Sea	48	14	1	168	11	0
EEZ < 10 mi	14	96	5	6	33	0
EEZ ≥ 10 mi	0	3	151	0	0	5

Table 7. Species composition of sea turtles in observed trawl catches north and south of Cape Hatteras in the summer flounder fishery, November, 1991 - February, 1992. Deaths are indicated in parenthesis.

Species	November-December, 1991		January-February, 1992		Total
	North	South	North	South	
Caretta caretta	11(2)	15(2)	4	20(1)	50(5)
Lepidochelys kempi	2	26(1)		2	30(1)
Chelonia mydas		1		1	2
Eretmochelys imbricata		1(1)			1(1)
all species	13(2)	43(4)	4	23(1)	83(7)

Table 8. Catch rates of sea turtles (turtles per standard net hour) in the summer flounder trawl fishery, November, 1991 - February, 1992, in nets without TEDs. The unweighted overall catch rate for the entire fishery operating south of Cape Charles was 0.0480 turtles per standard net hour.

	North of Cape Charles	Cape Charles to Cape Hatteras	Cape Hatteras to Cape Lookout
November - December, 1991			
Caretta caretta	0	0.0173	0.0659
Lepidochelys kempi	0	0.0032	0.1036
Chelonia mydas	0	0	0.0047
all species	0	0.0205	0.1742
January - February, 1992			
Caretta caretta	0	0.0093	0.0485
Lepidochelys kempi	0	0	0.0023
Chelonia mydas	0	0	0.0046
all species	0	0.0093	0.0554
overall	0	0.0167	0.0945

Table 9. Estimated total mortality of sea turtles in the summer flounder trawl fishery, November, 1991 - February, 1992. Where appropriate, ranges are given for each estimate based on the assumption that resuscitated turtles all lived or all died.

	State Where Trip Was Landed		
	North Carolina	Virginia	Total
November - December, 1991			
Caretta caretta	28-56	38-38	66-94
Lepidochelys kempi	0-56	0-0	0-56
Chelonia mydas	0-0	0-0	0-0
Eretmochelys imbricata	14-14	0-0	14-14
January - February, 1992			
Caretta caretta	9-17	0-0	9-17
Lepidochelys kempi	0-0	0-0	0-0
Chelonia mydas	0-0	0-0	0-0
Eretmochelys imbricata	0-0	0-0	0-0
all species	51-143	38-38	89-181

Table 10. Estimated number and density of sea turtles on the surface of North Carolina nearshore waters from aerial surveys, November, 1991 - March, 1992. Total area of each zone is indicated in parenthesis.

Survey Area / Date	Time (EST) at Beginning of Survey	Number of Turtles Sighted Within Area Surveyed	Area Surveyed (km^2)	Estimated Number of Turtles on Surface: Number	Estimated Number of Turtles on Surface: Std. Error of Mean	Estimated Density of Turtles on Surface: Turtles/100km^2	Estimated Density of Turtles on Surface: Std. Error of Mean
Beach to 3 miles Offshore							
N.C./Va. line to Currituck Bridge (287 km^2)							
Nov 15, 1991	11:54	0	65	0	-	0	-
Currituck Bridge to Oregon Inlet (223 km^2)							
Nov 15, 1991	14:19	0	49	0	-	0	-
Oregon Inlet to Cape Hatteras Pt. (348 km^2)							
Nov 19,1991	10:47	0	79	0	-	0	-
Cape Hatteras Pt. to Ocracoke Inlet (266 km^2)							
Nov 19, 1991	14:16	0	66	0	-	0	-
Dec 12, 1991	10:41	3	136	1.95	1.69	0.73	0.55
Ocracoke Inlet to Cape Lookout Pt. (404 km^2)							
Nov 14, 1991	10:47	11	95	25.60	10.98	6.34	2.55
Beach to 15 miles Offshore							
Oregon Inlet to Cape Hatteras Pt. (1711 km^2)							
Dec 8, 1991	9:58	17	196	140.02	45.28	8.18	2.57
Jan 30, 1992	12:06	11	193	79.87	32.90	4.67	1.90
Mar 3, 1992	10:27	22	195	140.06	55.93	8.19	3.18
Mar 30, 1992	11:48	0	196	0	-	0	-
Cape Hatteras Pt. to Ocracoke Inlet (1016 km^2)							
Dec 7, 1991	10:43	3	113	26.93	19.36	2.65	1.82
Feb 4, 1992	9:58	6	228	13.40	6.19	1.32	0.58
Feb 22, 1992	10:29	42	221	110.31	50.73	10.85	4.88
Mar 9, 1992	10:23	12	245	33.13	14.52	3.26	1.38
Ocracoke Inlet to 5 mi south of Drum Inlet (1779 km^2)							
Jan 8, 1992	11:53	24	206	181.18	28.63	10.18	1.58
Ocracoke Inlet to Cape Lookout Pt. (2381 km^2)							
Feb 21, 1992	10:13	14	276	120.56	24.93	5.06	1.02

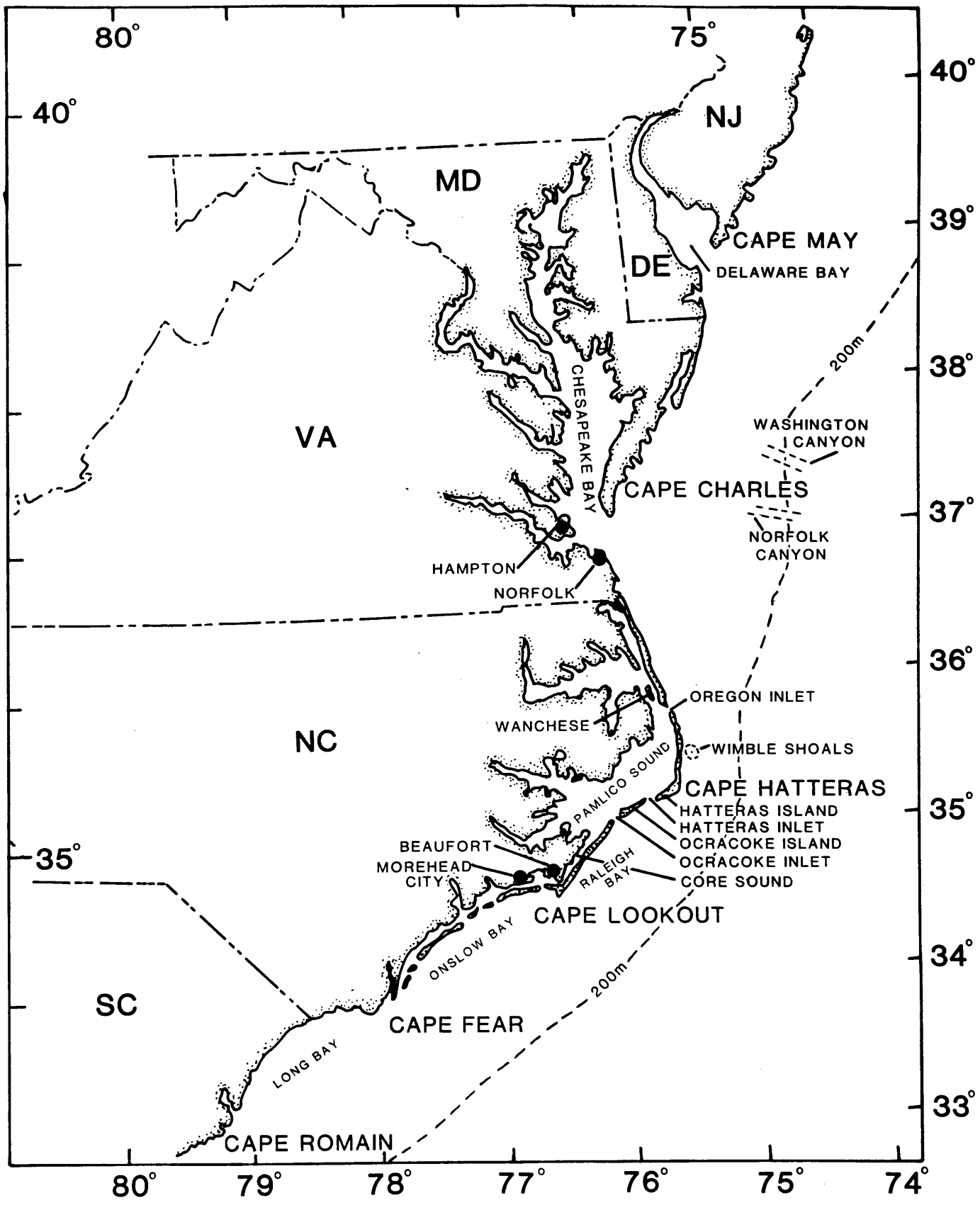


Figure 1. The central Atlantic coast of the United States.

Figure 2. Satellite images of sea surface temperature between Cape Charles, Va. and Cape Romain, S.C. The advanced, very high resolution radiometer was flown on the NOAA-11 polar-orbiting satellite. Magenta areas are cloud cover. White areas denote temperatures >25.3°C. See Fig. 1 for references made to landmarks, inlets, and water bodies.

A) SST image 25 November, 1991. The western edge of the Gulf Stream is parallel to the edge of the continental shelf and is depicted as dark red (lower left to upper right diagonal).

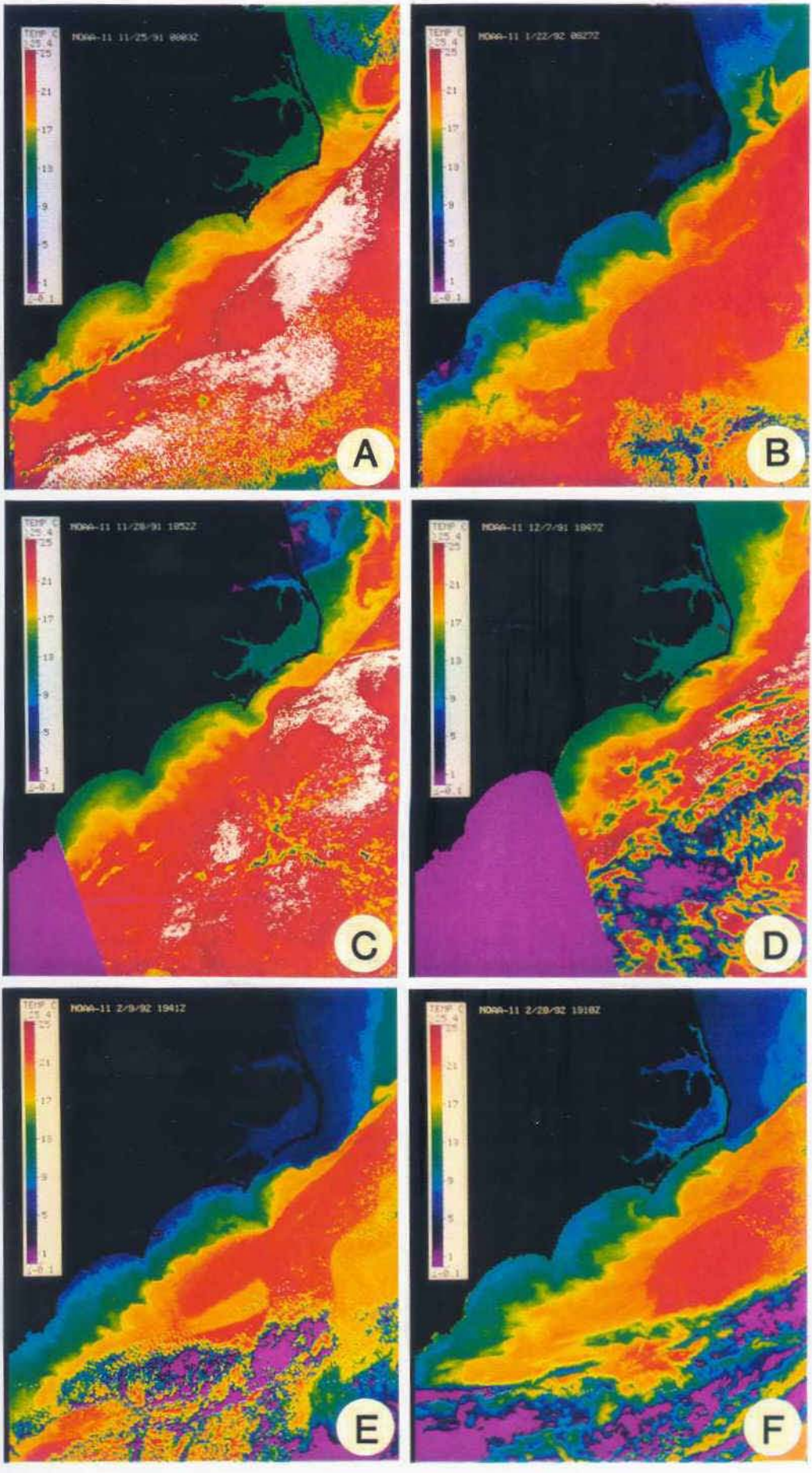
B) SST image 22 January, 1992. Note the presence of Gulf Stream water (>5°C higher) on the continental shelf north of Cape Hatteras.

C) SST image 28 November, 1991. Early stage of Gulf Stream meander. The outpocketing of the western edge of the Gulf Stream is evident in Raleigh Bay.

D) SST image 7 December, 1991. Late stage of Gulf Stream meander. Filaments of Gulf Stream water override the cold, dense shelf water and penetrate the entire width of the shelf, reaching nearshore waters.

E) SST image 9 February, 1992. Virginian Coastal Water (5°C) has been pushed around Cape Hatteras and into Raleigh Bay by strong winds from the north and northeast (see Fig. 3). The Gulf Stream is forced away from Cape Hatteras.

F) SST image 20 February, 1992. Upon relaxation of northerly winds (see Fig. 3), Virginian Coastal Water is less evident in Raleigh Bay. The Gulf Stream is now closer to Cape Hatteras.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A
NOAA-11 1/22/92 0827Z
B
NOAA-11 11/28/91 1852Z
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D
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E
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F

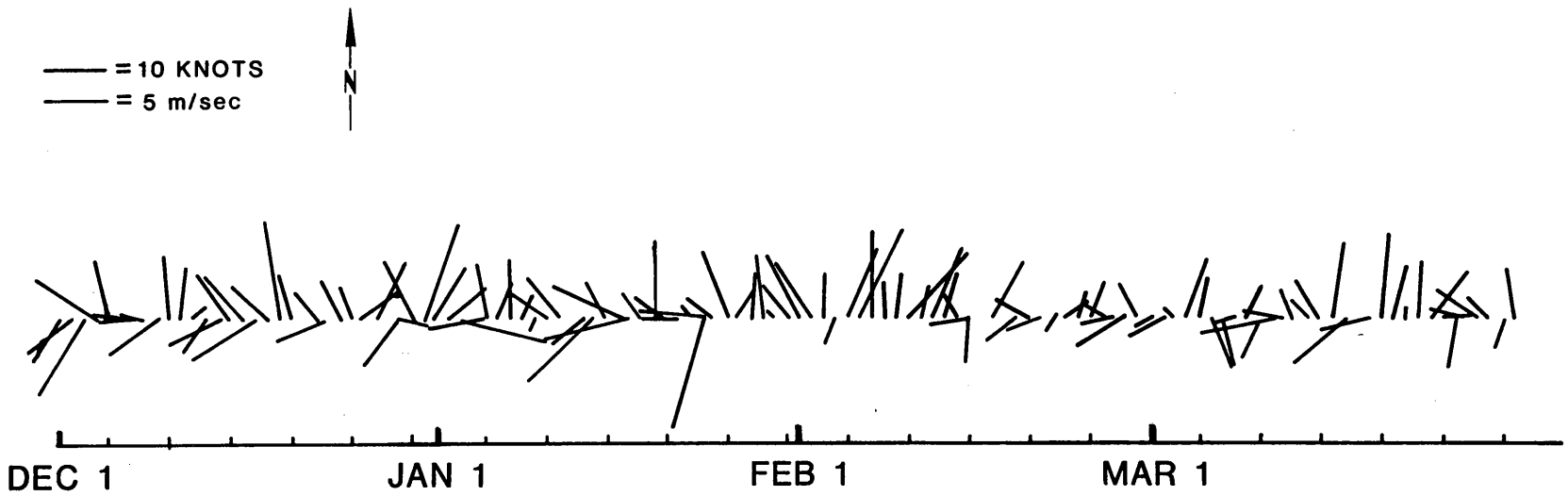


Figure 3. Daily mean wind speed and direction recorded at National Weather Service station in Buxton, N.C. (Cape Hatteras), from 1 December, 1991 through 31 March, 1992. Vectors indicate the direction from which the wind was blowing.

Figure 4. Tracks of observed hauls of the summer flounder fishery, November, 1991-February, 1992. Boundaries drawn 6 km (3 nm) and 18 km (10 nm) from shore denote the seaward boundaries of North Carolina's territorial sea and the area of the EEZ in which tow times were restricted, respectively.

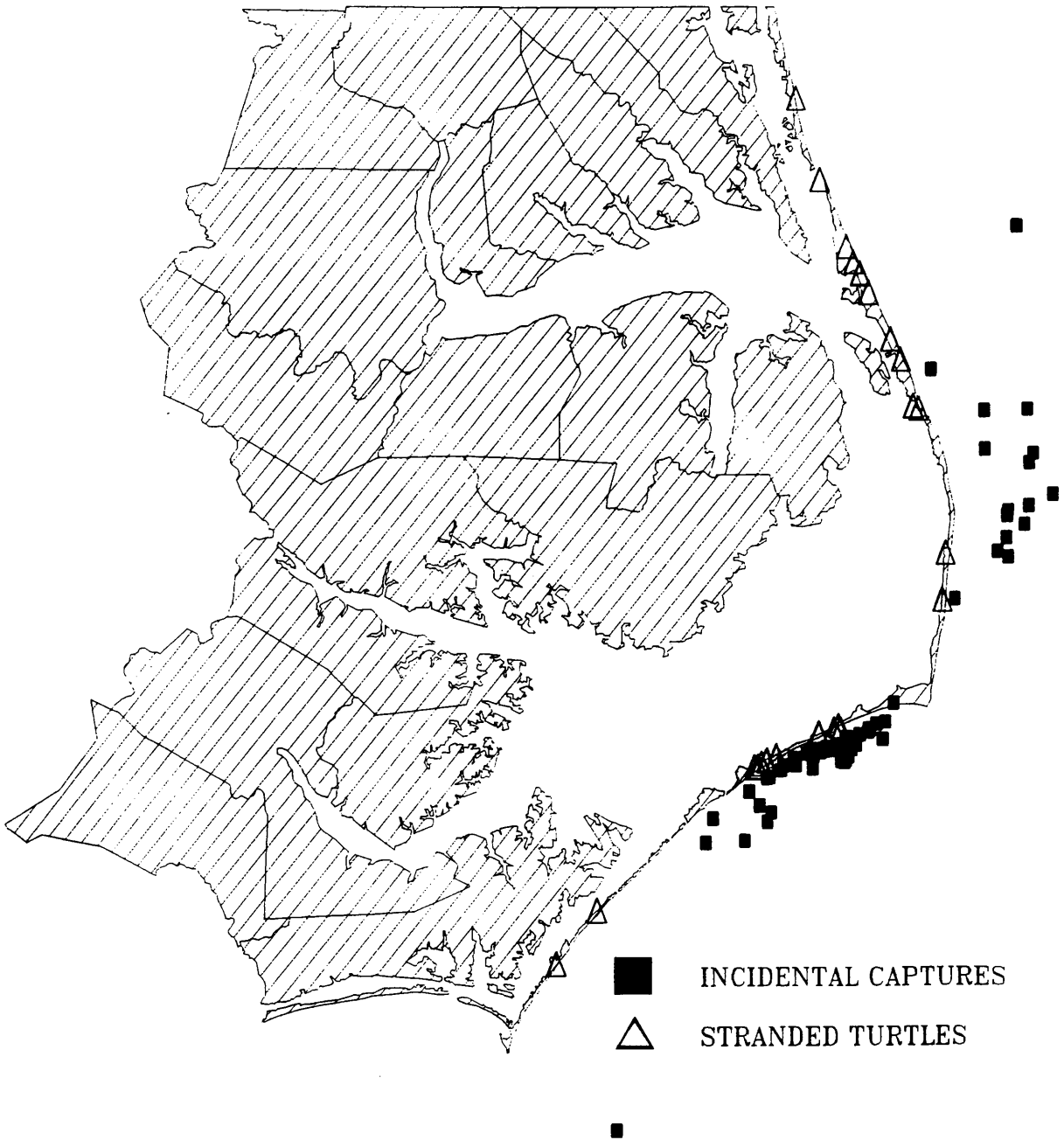


Figure 5. Locations of incidental catches of sea turtles in the summer flounder trawl fishery (November, 1991-February, 1992) and of turtles reported stranded on the ocean beaches (October, 1991-April, 1992).

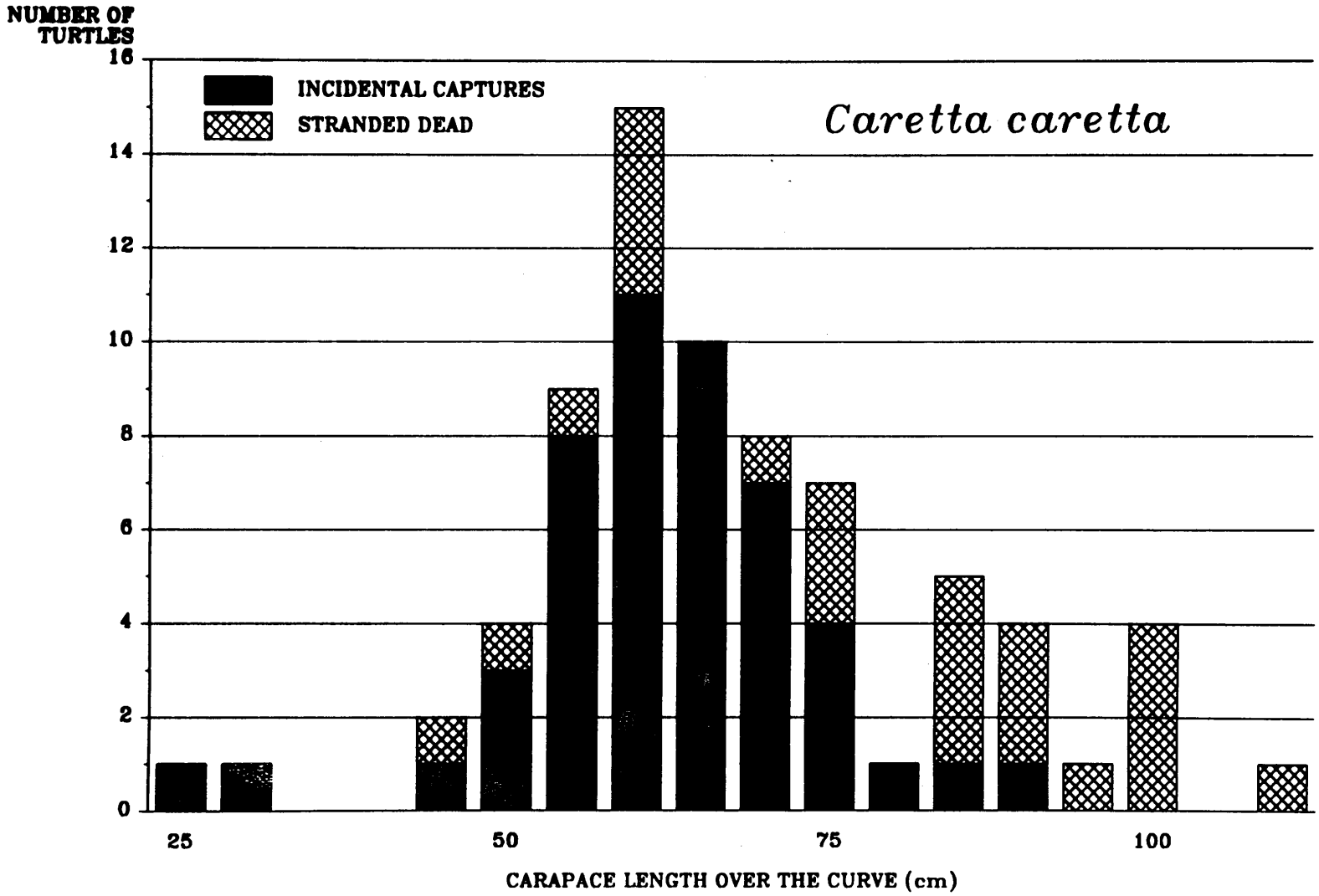


Figure 6. Size frequencies of loggerhead sea turtles, Caretta caretta, caught in the summer flounder trawl fishery (November, 1991-February, 1992) and of loggerhead sea turtles reported stranded on ocean beaches (October, 1991-April 1992).

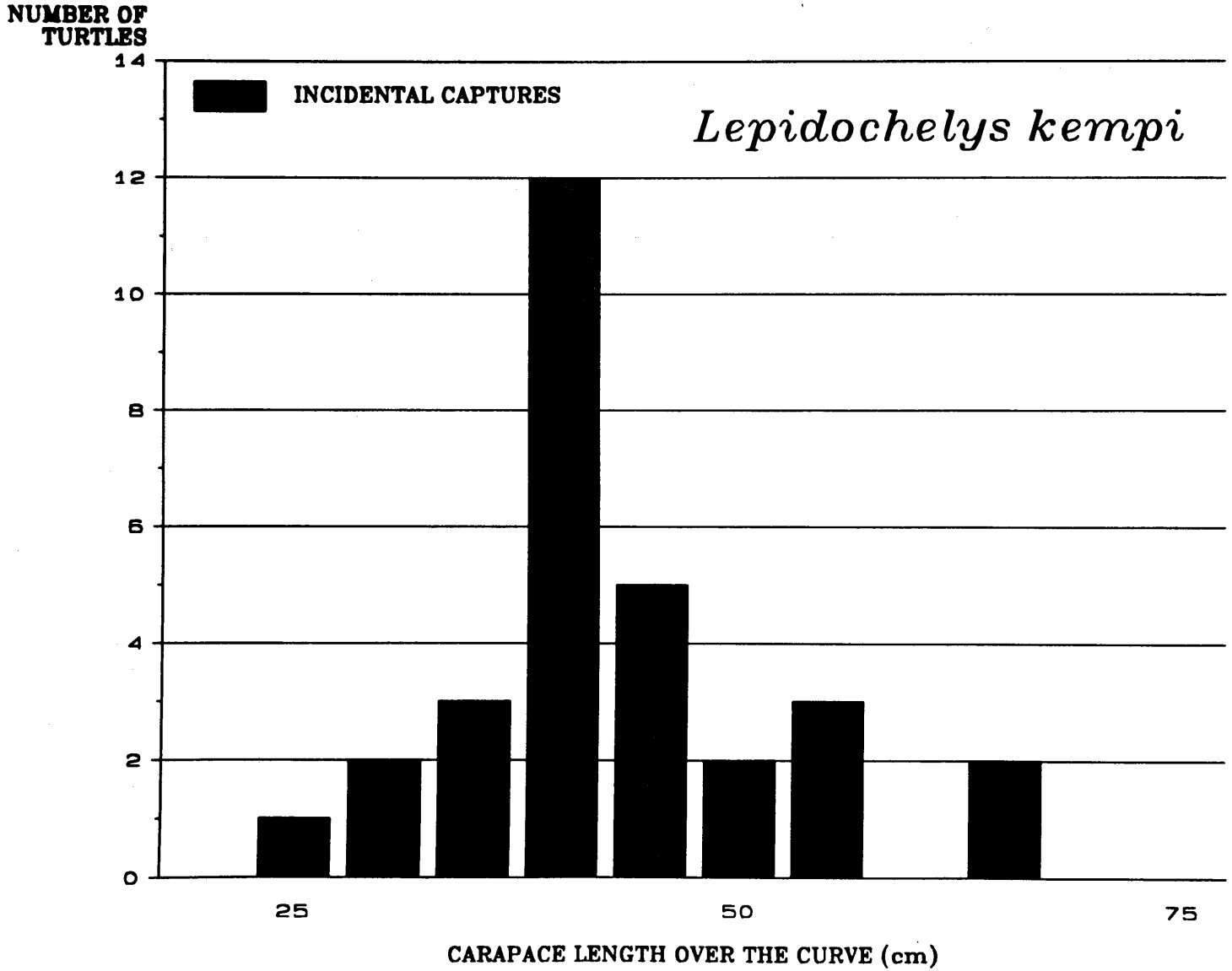


Figure 7. Size frequency of Kemp's ridley sea turtles, Lepidochelys kempi, caught in the summer flounder trawl fishery, November, 1991-January, 1992.

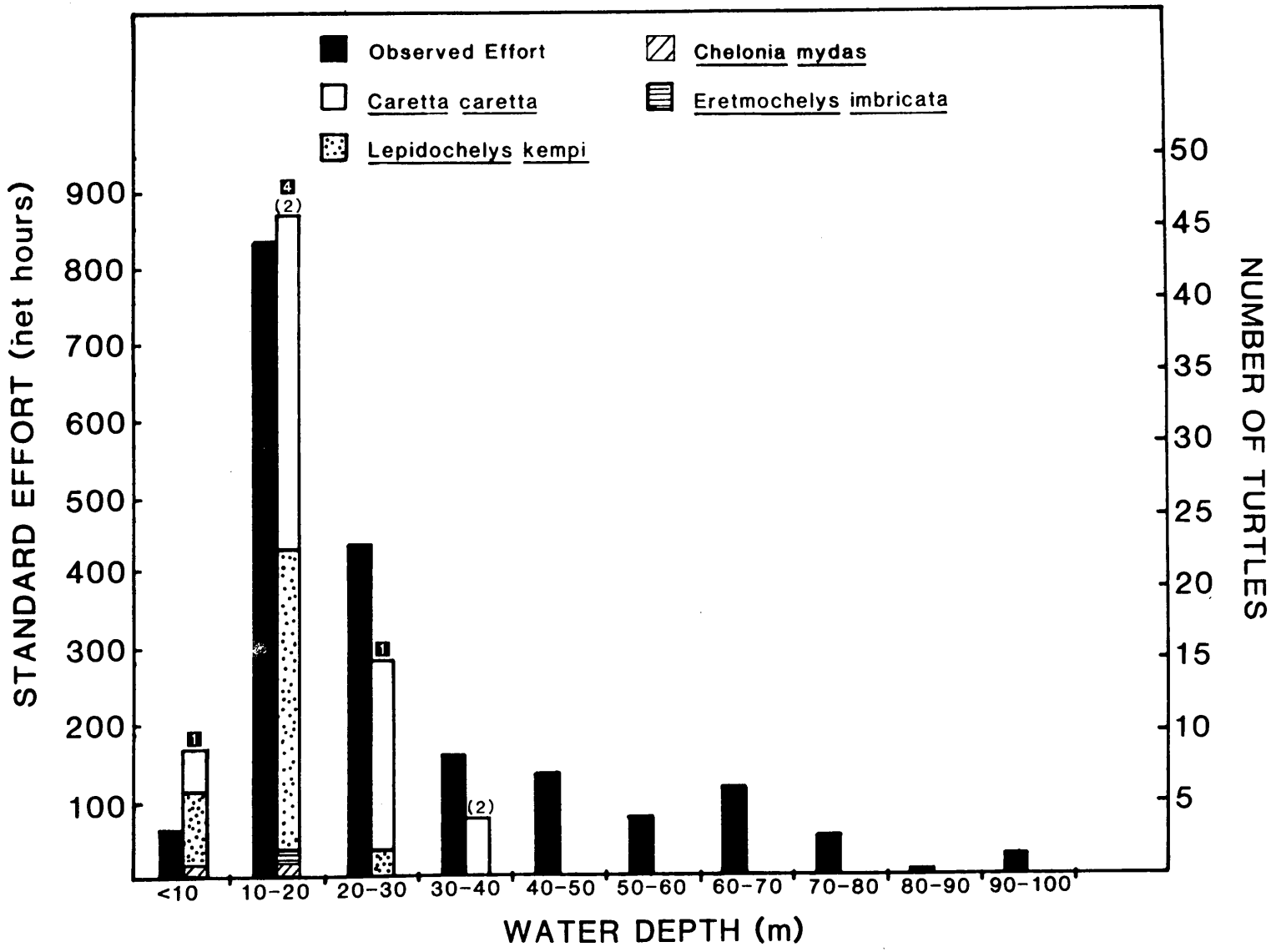


Figure 8. Standard effort and catch of sea turtles in the summer flounder trawl fishery, November, 1991-February, 1992, as a funtion of depth. Deaths are indicated in parenthesis and resuscitated turtles are indicated in solid boxes.

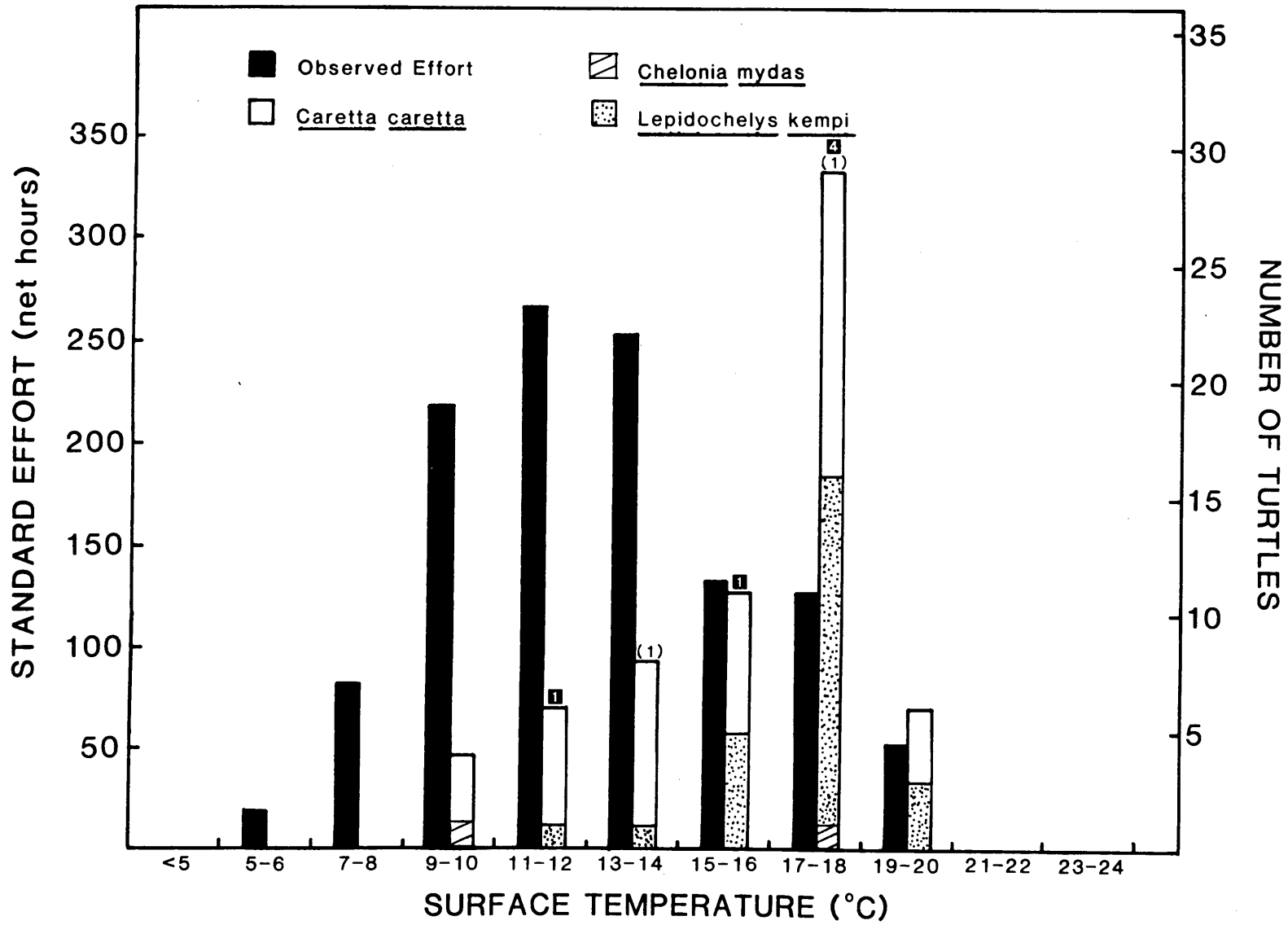


Figure 9. Standard effort and catch of sea turtles in the summer flounder trawl fishery, November, 1991-February, 1992, as a function of water temperature. Deaths are indicated in parenthesis and resuscitated turtles are indicated in solid boxes.

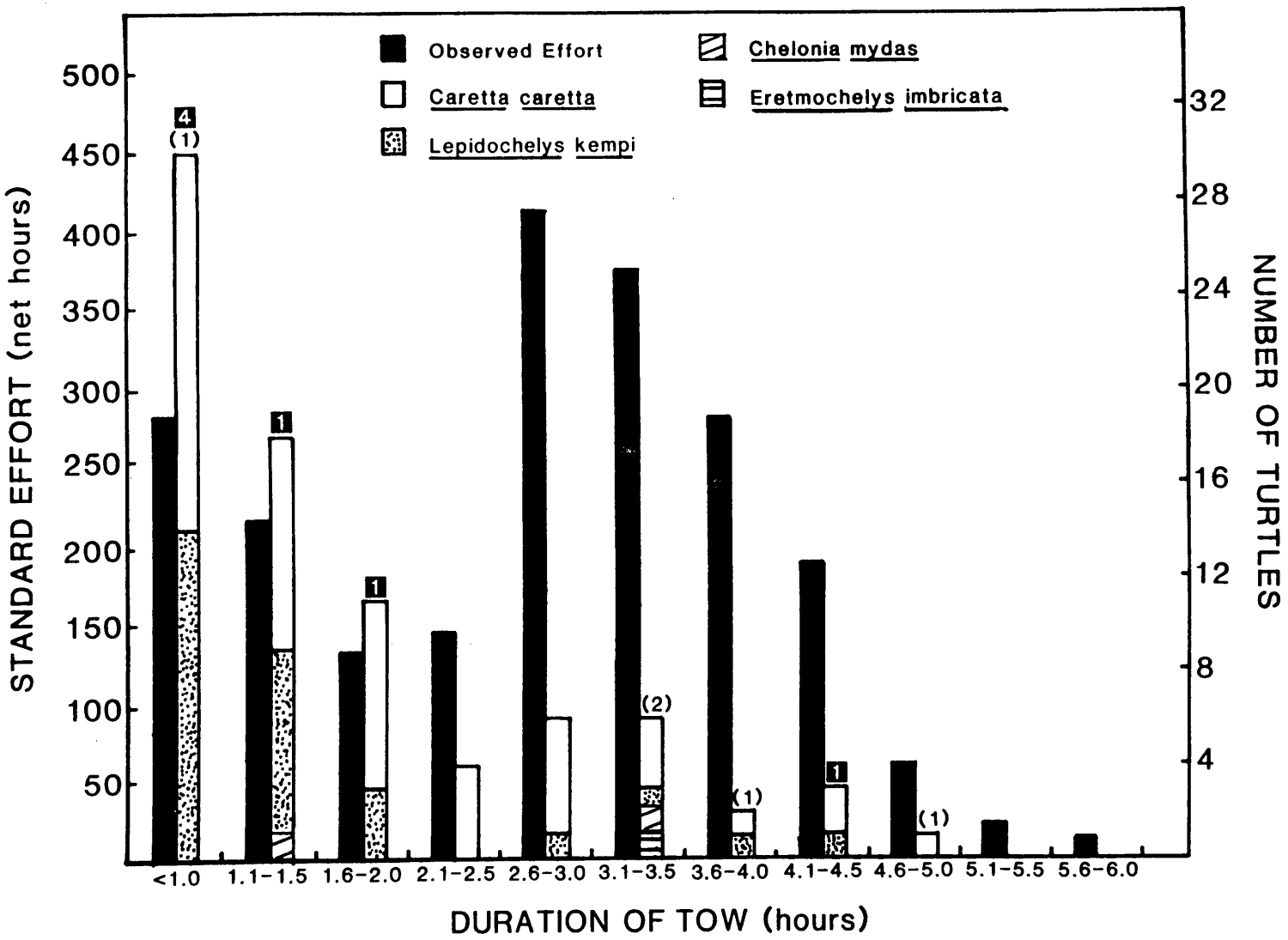


Figure 10. Standard effort and catch of sea turtles in the summer flounder trawl fishery, November, 1991-February, 1992, as a function of duration of tow. Deaths are indicated in parenthesis and resuscitated turtles are indicated in solid boxes.

Figure 11. Satellite images of sea surface temperature between Cape Charles, Va. and Cape Romain, S.C., and sightings of sea turtles in North Carolina waters. Magenta areas are cloud cover. White areas denote temperatures >25.3°C. See Fig. 1 for references made to landmarks, inlets, and water bodies.

A) SST image 7 December, 1991. Sea turtles were sighted and caught in warm waters which reached the beach, both north and south of Cape Hatteras. Sightings and captures occurred as far north as the Wimble Shoals area.

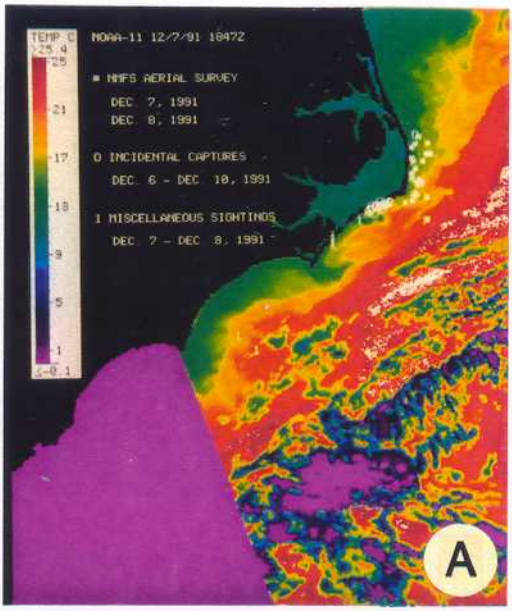
B) SST image 8 January, 1992. Sea turtles appeared associated with the strong thermal gradient in Raleigh Bay, south of Ocracoke Inlet. Note the absence of sightings immediately adjacent to the beach were temperatures were approximately 9-10°C.

C) SST image 21 January, 1992. Sea turtles were sighted during the marine mammal survey conducted between Cape Hatteras and Cape Fear by NMFS, Miami Laboratory. The Gulf Stream is farther offshore in the southern area of the survey and the nearshore waters are colder. The distribution of sea turtles paralleled that of the Gulf Stream waters over the continental shelf. Note the presence of Gulf Stream water on the shelf north of Cape Hatteras and the sighting of a sea turtle north of Oregon Inlet (The sighting was by a trained observer conducting directed vessel overflights).

D) SST image 30 January, 1992. Sea turtles were sighted during the marine mammal survey conducted over Raleigh and northern Onslow Bay and during the NMFS aerial survey north of Cape Hatteras. Temperatures south of Cape Lookout appear cool due to cloud cover. Turtles appear associated with Gulf Stream waters and appear farther from shore in Onslow Bay and southern Raleigh Bay. Note the capture and sighting of sea turtles in relatively cold water north of Cape Hatteras.

E) SST image 20 February, 1992. Sea turtles were especially abundant along the strong thermal gradient between the Virginian Coastal Water and the waters of the Gulf Stream.

F) SST image 2 March, 1992. Sea turtles were sighted between Oregon Inlet and Ocracoke Inlet, including in 6°C water north of Cape Hatteras. Note the retraction of Virginian Coastal Water northward when compared to its position as shown in Figs. 2F and 11E.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25
21
17
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DEC. 8, 1991
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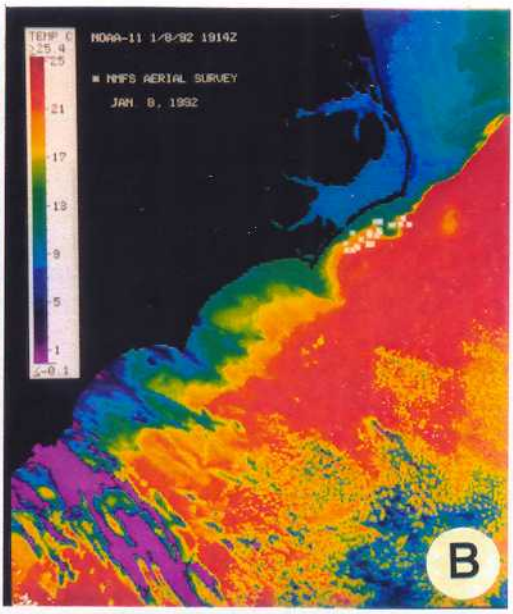
DEC. 6 - DEC. 10, 1991
1 MISCELLANEOUS SIGHTINGS
DEC. 7 - DEC. 8, 1991
A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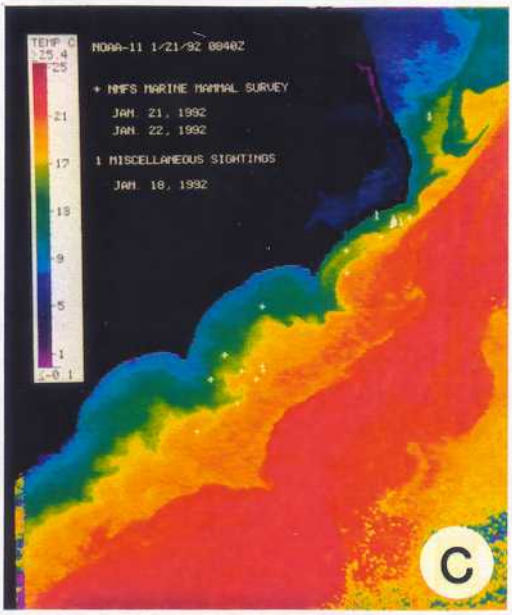
JAN. 8, 1992
B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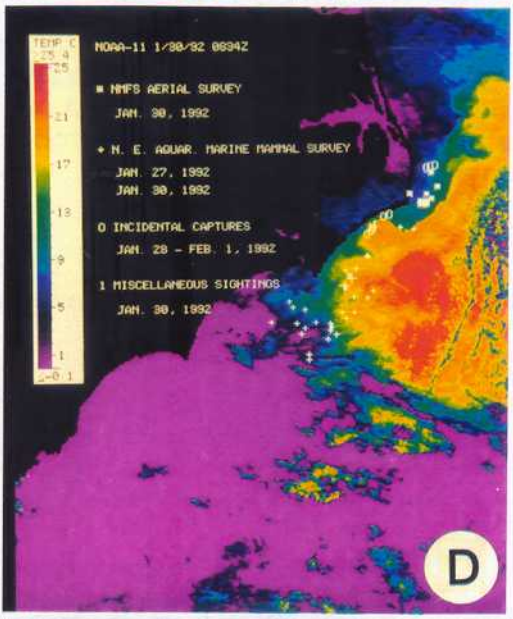
1 MISCELLANEOUS SIGHTINGS
JAN. 18, 1992
C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+ N. E. AQUAR. MARINE MAMMAL SURVEY
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JAN. 28 - FEB. 1, 1992
1 MISCELLANEOUS SIGHTINGS
JAN. 30, 1992
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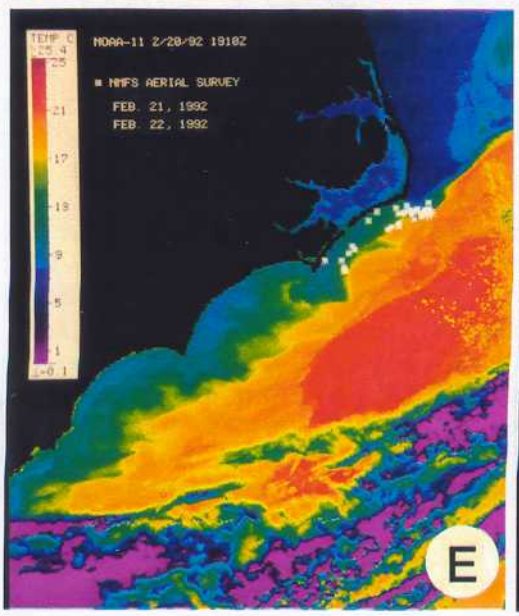
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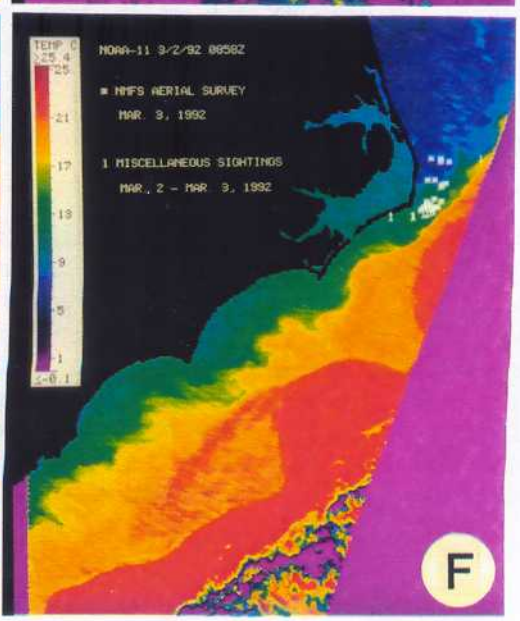
FEB. 21, 1992
FEB. 22, 1992
E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MAR. 3, 1992
1 MISCELLANEOUS SIGHTINGS
MAR. 2 - MAR. 3, 1992
F

APPENDIX A

NORTH CAROLINA DIVISION OF MARINE FISHERIES/NATIONAL MARINE FISHERIES SERVICE COOPERATIVE SEA TURTLE MONITORING AND ACTION PLAN

To protect threatened and endangered species of sea turtles in the Atlantic Ocean off North Carolina, the North Carolina Division of Marine Fisheries, (DMF) and National Oceanic and Atmospheric Administration (NOAA) - National Marine Fisheries Service (NMFS) will monitor the activities of the winter trawl fishery for summer flounder. Monitoring activities and fishery management actions will intensify when there is a potential for sea turtles to be present in areas where trawling is occurring. Annually, sea turtles from the mid-Atlantic states and North Carolina inshore areas migrate southward to wintering grounds offshore or south of Cape Lookout. The shelf and nearshore migratory corridor area for sea turtles also supports an active trawl fishery for summer flounder during the fall and winter between Cape Henry, Virginia and Cape Lookout. The goal of this action plan is to provide a framework and operational process to protect sea turtles during their migration southward while concurrently allowing continuation of the traditional flounder fishery in the coastal waters of North Carolina.

An advisory committee composed of representatives from state and federal agencies and fishing interests will be appointed to implement the sea
turtle monitoring and action plan. This committee will collect and review data on sea water temperatures, turtle distribution and movements, and fishery activity. Further, they will advise DMF and NMFS Southeast Regional Office (SERO) on recommended actions to protect sea turtles and optimize traditional fishery opportunities. The committee will communicate at least bi-weekly during the critical period.

Monitoring will occur from October 15 through January 15, which is the time that sea turtles migrate southward and the North Carolina trawler fleet fishes for summer flounder in nearshore waters from Oregon Inlet to Ocracoke in depths up to ten fathoms and in deep water from Virginia to Oregon Inlet in depths up to 100 fathoms.

Data on sea surface temperature (SST) derived from thermal infrared satellite imagery is available through the NMFS Southeast Fisheries Science Center Laboratory in Beaufort. Weekly summary plots beginning in mid- September will be used in reviews. Monitoring of daily images will occur for the presence of warm water eddies moving westward from the Gulf Stream into coastal waters. Early identification of conditions which may delay the usual southward or seaward migration of turtles during the fall will prompt monitoring and action measures to protect the turtles.

The water temperatures in the area between Oregon Inlet and Cape Lookout will receive particular attention. The data indicate that when water temperatures are above 12°C during this time frame aerial monitoring should be conducted daily, and turtle protection measures should be instituted.

Aerial surveys by DMF will be conducted at least twice weekly from 15 October on to monitor the location and number of trawlers working in the area and the presence of sea turtles. The Virginia Institute of Marine Science (VIMS) conducts aerial surveys of the lower Chesapeake Bay and Virginia coastal waters for sea turtles. The DMF observers will be trained in sea turtle aerial survey methodology by NOAA or VIMS personnel. Aerial Survey, water temperature and other available information will be used by the committee to track the north-south movement of sea turtles.

NOAA-NMFS-Beaufort Laboratory data from ongoing aerial survey, public sightings, and cooperating pound net fishermen on abundance, location and species composition will be used to indicate timing and extent of emigration from the inshore areas.

ACTIONS

When it is determined that turtles are present in the trawling area by (a) aerial survey, or (b) onboard agency observers, the DMF Director, in consultation with NMFS, will immediately take appropriate action. Monitoring will intensify to include daily aerial surveys of fleet and turtle locations, observers will be placed aboard selected vessels, satellite imagery will continue to be reviewed and the Stranding Network will be alerted. If turtles are observed in close proximity to trawling activity and/or special conditions warrant it, the Director in consultation with NMFS, will require that trawlers limit their tow times to 60 minutes (bottom time) to be enforced and monitored by observers on selected vessels. The Division's 44-foot research vessel will be dispatched and conduct independent trawling and flounder tagging. If observers continue to encounter turtles in the trawls and if tow times are not being adhered to, the DMF Director will require that turtle excluder devices be installed in flounder trawls. Excluders will have six inch spacing between bars as utilized in December, 1990. As a final measure, the Director will close the area to trawling or take other steps to ensure the safety of the turtles as authorized by North Carolina Marine Fisheries Rule 15A NCAC 3I .0007.

Monitoring during an area/fishery closure will include aerial surveys for turtle locations and trawler violations, examination of satellite thermal imagery, and periodic DMF-monitored experimental trawling with and without TEDs to ground-truth the turtle presence in the area.

When temperature, aerial surveys, and test trawling indicate turtles have dispersed or moved out of the area, the committee will recommend that the Director, in consultation with NMFS, reopen the area to less restricted fishing.

The committee will submit a summary report for the fishing season of conditions and actions taken, if any, to NMFS, SERO Director and the Secretary of the North Carolina Department of Environmental Health and Natural Resources.

Proposed Advisory Committee:

NCDMF - Bill Hogarth, Fentress Munden, David Taylor, Wayne Maxwell, Harrel Johnson, Mike Street
NMFS - Ford Cross/John Merriner, Joanne Braun, Sherry E. Chester, Pat Tester
NPS - Ries Collier
NCWRC - Tom Henson
INDUSTRY - Jerry Schill

APPENDIX B

CHRONOLOGY OF MANAGEMENT ACTIONS
FOR THE SUMMER FLOUNDER TRAWL FISHERY
OCTOBER, 1991 - MARCH, 1992

28 October 1991 North Carolina Department of Environment, Health and Natural Resources, Division of Marine Fisheries Proclamation FF-12-91 effective implementing tailbag mesh sizes and restricting tow times of trawl fisheries (flynets exempt) in state waters from the NC/VA state line to Ocracoke Inlet. Tow times restricted to 60 min bottom time with 75 min allowed to set, tow and retrieve nets. Notifies fishermen that vessels fishing in the fishery may be required to allow NCDMF observers aboard vessels. Expires April 30, 1992.

2 December 1992 U.S. Department of Commerce, NOAA, National Marine Fisheries Service Emergency Interim Rule effective (56 FR 63685, December 5, 1991; corrected 56 FR 66603, December 24, 1991; revised 57 FR 212, January 3, 1992 and corrected 57 FR 4248, February 4, 1992; corrected 57 FR 6297, February 24, 1992; extended 57 FR 8582, March 11, 1992). The emergency interim rule provides for minimum net mesh-size restrictions for the summer flounder trawl fishery, exemptions to the minimum mesh size restrictions, and framework management for the conservation of sea turtles taken incidentally in the fishery. As a sea turtle conservation measure the rule restricts tow times between 37°05′N and 33°35′N in the EEZ to 10 miles from shore. Tow times are restricted to 75 min measured from the time trawl doors enter the water until they are removed from the water. Effective through March 5, 1992.

11 November 1991 North Carolina Department of Environment, Health and Natural Resources, Division of Marine Fisheries Proclamation FF-19-91 effective (supercedes FF-12-91). Implements tailbag mesh sizes and restricts tow time of trawl fisheries (flynets exempt) in state waters from the NC/VA state line to Ocracoke Inlet. Tow times restricted to maximum of 60 min bottom time with 75 min allowed to set, tow and retrieve nets. Also provides for use of NMFS or NCDMF approved TEDs, in lieu of tow time restrictions, with a permit obtained from Division of Marine Fisheries. Requires boats permitted and equipped with TEDs to keep a harvest log book showing the date, location, tow time, turtles captured, and catch size. Notifies fishermen that vessels participating in fishery may be required to carry NCDMF/NMFS observers. Expires April 30, 1992. Note: 14 TED permits were issued throughout the season.

11 December 1991 North Carolina Department of Environment Health and Natural Resources, Division of Marine Fisheries Fisherman's Advisory. Alerts fishermen to the presence of sea turtles in fishing area and informs fishermen of existing state and federal regulations restricting tow times to conserve sea turtles. Notice advises of increased enforcement efforts and notifies fishermen of provisions for placement of observers.

26 December 1991 North Carolina Department of Environment Health and Natural Resources, Division of Marine Fisheries Proclamation FF-23-91 effective. Exempts finfish trawling in state waters north of Oregon Inlet (35°45'N) from tow time restrictions and implements tailbag mesh sizes in state waters from the NC/VA state line to Cape Lookout (flynets exempt). It also requests voluntary observer coverage of 25% but provides for mandatory coverage should voluntary participation be inadequate. Proclamation FF-19-91 remains in effect south of Oregon Inlet to Ocracoke Inlet.

27 December 1991 U.S. Department of Commerce, NOAA, National Marine Fisheries Service revision (57 FR 212, January 3, 1992; correction 57 FR 4248, February 4, 1992) to Emergency Interim Rule effective (56 FR 63685, December 5, 1991; corrected 56 FR 66603, December 24, 1991; corrected 57 FR 6297, February 24, 1992; extended 57 FR 8582, March 11, 1992). Removes tow time restrictions on vessels fishing in the area north of 35°45'N for the remainder of the effective period of the emergency regulations. Provides for the increase of observer coverage to 24% should sea turtles return to the fishing grounds off North Carolina.

17 January 1992 North Carolina Department of Environment Health and Natural Resources Division of Marine Fisheries Proclamation FF-3-92, in part, effective (supercedes FF-19-91 and FF-23-91). Implements tailbag mesh sizes (including possession of an undersized net aboard) in state waters from the NC/VA state line (36°33'N) to Cape Lookout (34°36'N) (flynets exempt) and restricts tow times (flynets exempt) in state waters between Oregon Inlet (35°45'N) and Cape Lookout (34°36'N). Tow times restricted to maximum of 60 min bottom time with 75 min allowed to set, tow and retrieve nets. Also provides for use of NMFS or NCDMF approved TEDs, in lieu of tow time restrictions, with a permit obtained from NCDMF. Requires boats permitted and equipped with TEDs to keep a harvest log book showing the date, location, tow time, turtles captured, and catch size. Expires April 30, 1992. Note: 14 TED permits were issued throughout the season.

24 January 1992 U.S. Department of Commerce, NOAA, National Marine Fisheries Service mandatory observer program effective. Letters, dated 14 January 1992, from Richard B. Roe, Northeast Region Director were mailed to 60 Summer Flounder Permit Holders. An additional 8 letters were mailed on 3 February 1992. The letters informed the permit holder that they must notify NMFS at least 48 hr in advance of each summer flounder trip taken through March 5, 1992 and if requested, they must carry an observer. Note: Four vessels were authorized to carry NCDMF observers on 100% of their trips in lieu of notifying NMFS prior to departing (letters dated 24 January 1992 from Richard B. Roe, Northeast Region Director).

24 January 1992 North Carolina Department of Environment Health and Natural Resources, Division of Marine Fisheries Proclamation FF-3-92, in part effective. Requires permits for all vessels participating in summer flounder fishery within state waters to possess either a Federal Flounder Permit or a NCDMF Flounder Permit. As a condition of the NCDMF Flounder Permit, all vessels are subject to the requirement that they carry NCDMF/NMFS observers. Requires 25% observer coverage. Vessels refusing to take observers will have permit revoked and will be subject to additional legal action. Expires April 30, 1992. Note: 9 permits were issued.

14 February 1992 U.S. Department of Commerce, NOAA, National Marine Fisheries Service withdrawal of the mandatory observer requirement for selected vessels participating in the summer flounder fishery, effective 1700 hours (1800 hours in press release). Announcement broadcast on NOAA Weather Radio and NMFS Radio (6230 and 8297 KHZ) on 13 and 14 February; press release from NMFS Northeast Regional Office dated 13 February 1992; letters to summer flounder permit holders from Richard B. Roe, Northeast Region Director, dated 18 February 1992; announcement message left on answering machine at phone number permit holders were to call to notify NMFS of pending trip.

16 February 1992 North Carolina Department of Environment Health and Natural Resources, Division of Marine Fisheries Proclamation FF-6-92 effective (supercedes FF-3-92). Implements tailbag mesh sizes (including possession of an undersized net aboard) in state waters from the NC/VA state line (36°33'N) to Cape Lookout (34°36'N) (flynets exempt) and restricts tow times (flynets exempt) in state waters between Oregon Inlet (35°45'N) and Cape Lookout (34°36'N). Tow times restricted to maximum of 60 min bottom time with 75 min allowed to set, tow and retrieve nets. Also provides for use of NMFS or NCDMF approved TEDs, in lieu of tow time restrictions, with a permit obtained from NCDMF. Requires boats permitted and equipped with TEDs to keep a harvest log book showing the date, location, tow time, turtles captured, and catch size. Notifies vessels participating in fishery that they may be requested to carry NCDMF/NMFS observers. The decision to carry observers is voluntary. Expires at midnight on or before April 30, 1992. Note: 14 TED permits were issued throughout the season.

6 March 1992 U.S. Department of Commerce, NOAA, National Marine Fisheries Service extension of Emergency Interim Rule (56 FR 63685, December 5, 1991; corrected 56 FR 66603, December 24, 1991; revised 57 FR 212, January 3, 1992 and corrected 57 FR 4248, February 4, 1992; corrected 57 FR 6297, February 24, 1992; extended 57 FR 8582, March 11, 1992). Interim regulations are extended from March 6, 1992 through June 3, 1992.

8 March 1992 North Carolina Department of Environment Health and Natural Resources, Division of Marine Fisheries Proclamation FF-10-92 effective (supercedes FF-6-92). Implements tailbag mesh sizes (including possession of an undersized net aboard) in state waters between NC/VA state line (36°33'N) and Cape Lookout (34°36'N) (flynets exempt). Expires April 30, 1992.